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By

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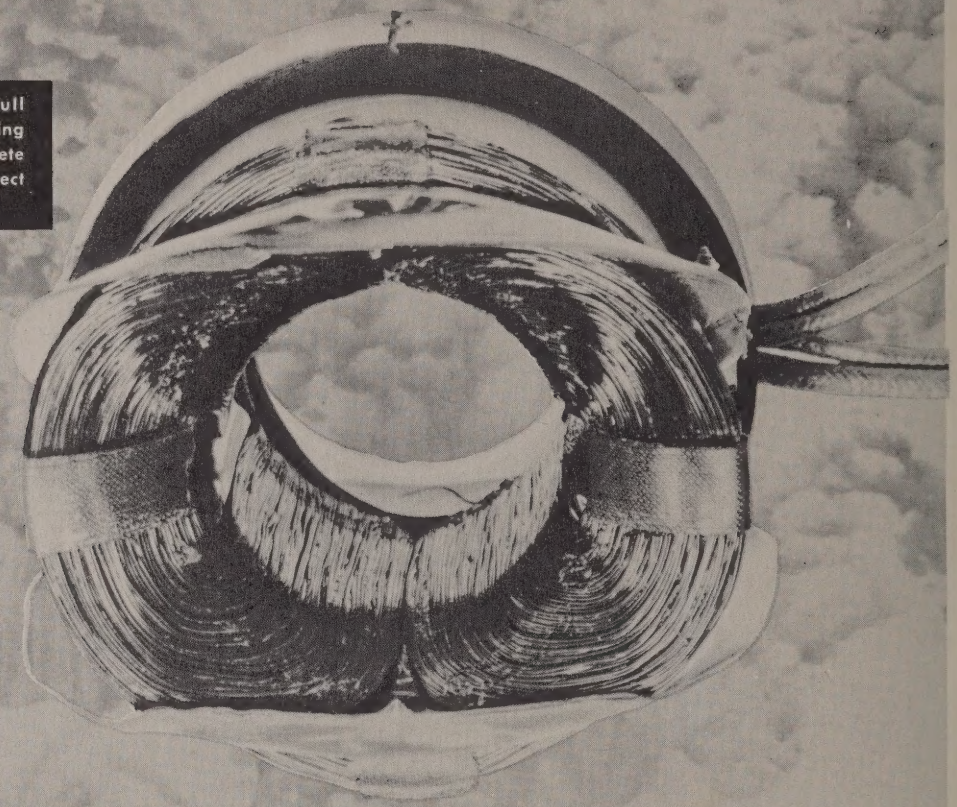

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2. How to Know Your Equipment.

3. How to Use Test Equipment with Specific Examples and Procedures.

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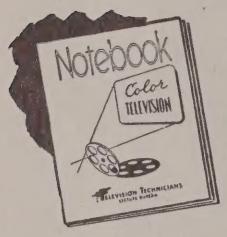

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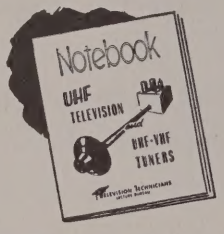

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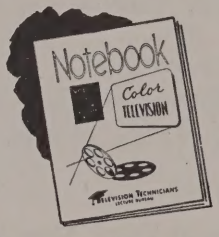

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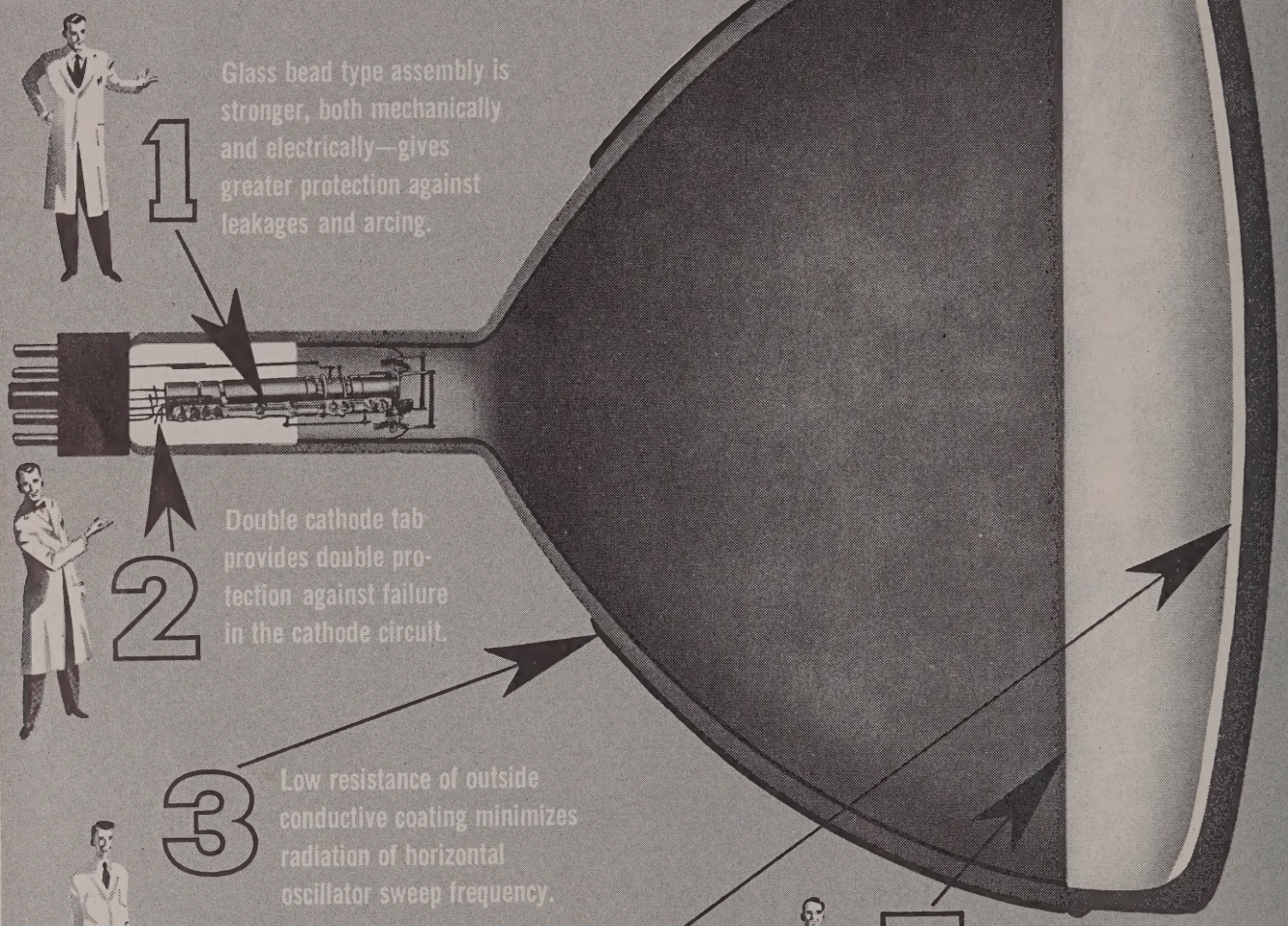

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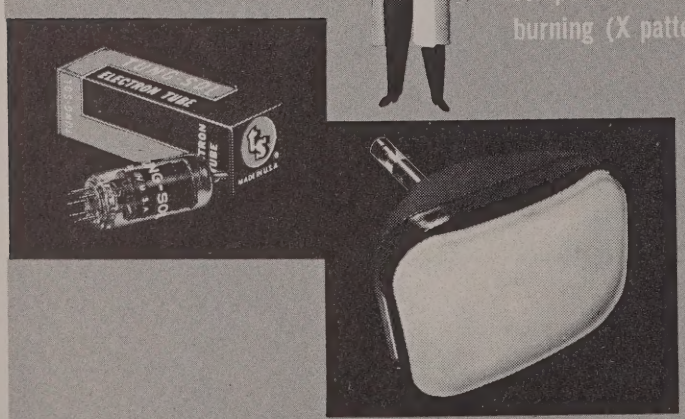

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INTRODUCTION

It is important we understand our test equipments to be able to use them with speed, precision, and utility. It is important to know what checks can be made, how to make them, and what limitations exist in the use of our instruments.

In this manual the electrical characteristics of test equipment are treated first. Theory of test equipment operation is not presented as this subject is discussed adequately in books, test equipment manuals, and other publications. Characteristics of test equipments are detailed with relation to their practical significance in the use of the equipment. Topics such as sensitivity, frequency response, input impedance, etc., are treated at length because they are important factors in the proper and accurate use of the equipment. Characteristics and special features of test equipments are set down to show you how they have been planned to serve the technician-serviceman with peak effectiveness.

A special "HOW-TO-DO-IT-CHART" has been prepared to permit you to locate quickly any specific check or procedure presented in the manual.

In succeeding sections practical application of test instruments in television receiver adjustment and repair is detailed step-by-step. Just how each instrument can be used individually and jointly with others is considered. Sections stress procedures and precautions giving you definite instructions and emphasizing these methods by direct application on a standard TV receiver.

Special sections of the manual that follow present a number of useful but perhaps uncommon uses for test equipment in television work. Inasmuch as test instruments contain tubes and components that age and go bad they too can cease to function properly. A number of check standards are discussed to permit you to check your test instruments quickly and accurately.

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IMPORTANT OSCILLOSCOPE CHARACTERISTICS

These are factors, Figure 1, of importance to know about your oscilloscope:

Sensitivity
Frequency Response
Input Impedance
Sweep Range
Sync and Sweep Arrangements

a. Sensitivity

The sensitivity of your scope tells you how strong and how weak a signal produces a useful undistorted indication on the screen. For television work it should be possible to see the re-

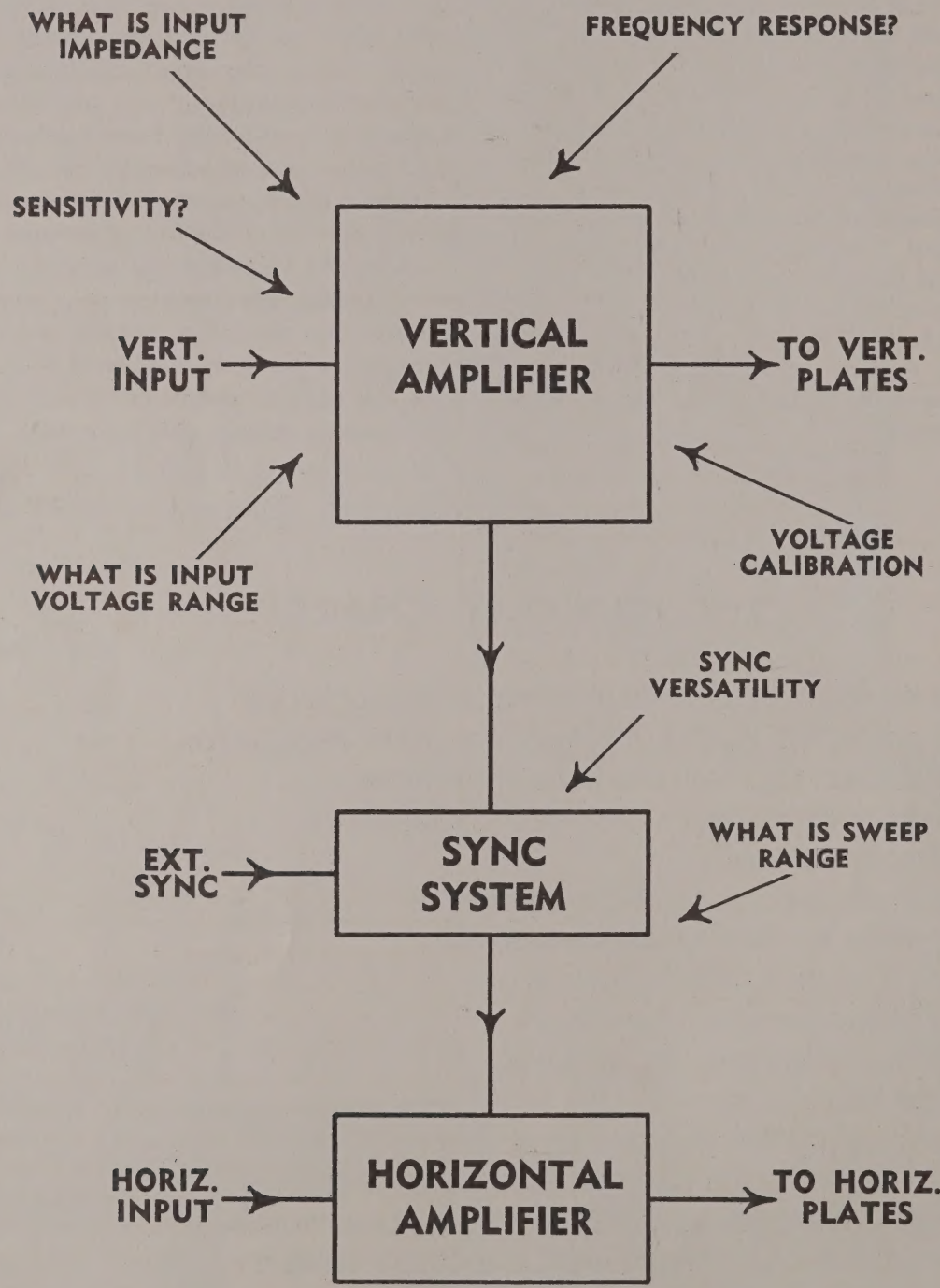


FIGURE 1. *Block Diagram of a Scope Showing Important Features*

sponse pattern of a single r-f or i-f stage using a standard sweep oscillator. This application requires a sensitive scope to amplify the very weak output of a single stage wideband amplifier. Many of our television waveforms in the sweep systems of the TV receiver are a few hundred volts and our scope must be able to bring these waveforms down to size (with suitable attenuation) to permit accurate viewing without distorting pulse shapes.

Sensitivity of the vertical amplifier of the scope is given in terms of r.m.s. volts per inch deflection. For example if a scope is said to have 100 millivolt/inch sensitivity it means that if a 100 millivolt (RMS) signal is applied with the vertical gain of the scope set to maximum and no input attenuation, a **one** inch high sine wave will appear on the screen. Note that both negative and positive peaks would be visible so scope is really a peak-to-peak voltage indicator. Peak-to-peak sine voltage is 282 millivolts or $100 \times 1.41 \times 2 = 282$. It is important to know that although sensitivity is given in terms of r.m.s. voltage the scope is a peak-to-peak indicating device. This must be taken into consideration when we measure pulse and sweep waveforms in our television receivers.

If a pulse is applied to scope, figure 2, and adjusted in amplitude until it is also **one** inch high it is said to have a peak amplitude of so many volts. It is now an easy step to understanding how we can use our scope to measure pulse and other non-sinusoidal wave-form amplitudes. Our standard a.c. meters can be used to measure sine waves conveniently and accurately. A scope by a comparison method can be used to measure non-standard a.c. signals and pulses. For example we can apply a pulse of unknown amplitude to our scope and adjust vertical gain control until pulse occupies a specific height, say **two** inches. Now pulse is removed but vertical gain control is **not touched.** Then an external 60 cycle sine is applied and its amplitude adjusted until it occupies a height of **two** inches also. Next an accurate a.c. meter is used to measure the amplitude of the sine that had to be applied to scope to obtain two inch deflection. Meter reads r.m.s. sine wave volts and to find peak amplitude of pulse this reading is multiplied by 2.82. Either an external sine wave source and meter can be used or, for peak utility, these facilities can be incorporated within the scope.

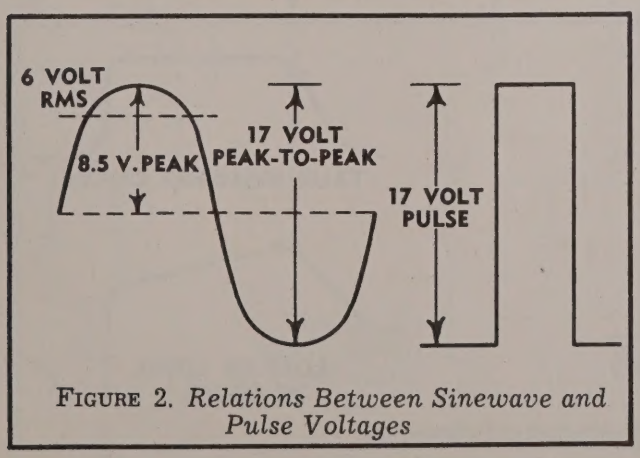


FIGURE 2. *Relations Between Sinewave and Pulse Voltages*

In television work it is necessary to measure high amplitude pulse waveforms and a suitable attenuator must be incorporated to permit reduction in level before application to input of vertical amplifier. It must do so without disturbing the shape of the waveform. At times, waveforms must be observed at points where there is present a high d.c. voltage. Input circuits must be able to withstand a high d.c. potential also.

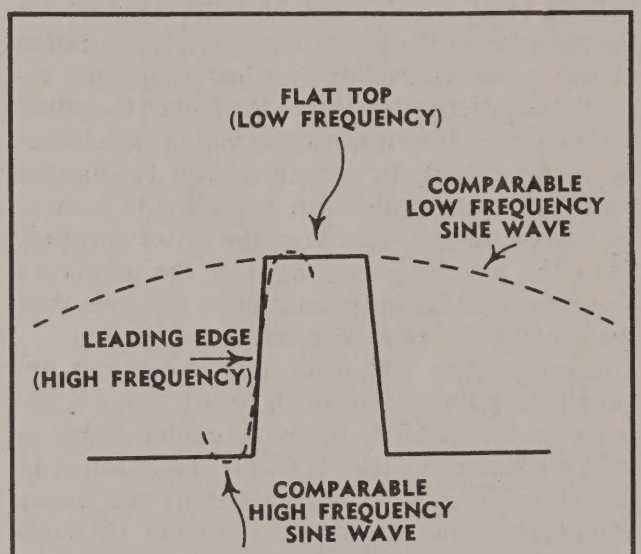


FIGURE 3. *Frequency Components of a Pulse*

b. Frequency Response

The vertical amplifier of the oscilloscope must have a wideband response to be able to pass the many frequency components that make up the television pulses and sweep waveforms. If some of the frequencies that make up a pulse are attenuated seriously or shifted in phase the pulse is distorted as it passes through the scope amplifier. Proper frequency response is necessary if you are to observe the television waveforms as they appear in the television receiver. Thus in checking for defects you can be assured that distortions are not contributed by your scope.

A rectangular pulse, figure 3, sawtooth wave or modified sweep waveform consists of a base

frequency and a number of low and high order harmonics depending on steepness and duration. For example the high frequencies present in a rectangular sync pulse depend on the speed with which the pulse rises from base line to peak level (leading edge) and speed with which it falls back to base line (trailing edge). The FCC standards tell us the commercial telecast sync pulses must rise in ¼ microsecond. This compares approximately with the time required by a 2 megacycle wave to rise from negative peak to positive peak. Thus the frequency components of our standard pulses extend to an upper limit somewhere between 1½ and 2 megacycles. To prevent fold-over of this leading edge, figure 4, vertical amplifier of scope must have a good response up to at least **two** megacycles or higher.

The flat-top of a pulse, figure 3, represents a low frequency because it represents a sustained voltage level which must be held constant for the duration of the pulse. Therefore the duration of the pulse determines the low frequency response requirements because the longer the pulse, the longer the time interval the voltage level must be held constant. To sustain a level flat-top the period of a comparable sine wave would have to be substantially longer than the pulse duration. Thus the low frequency limit of the amplifiers that must pass the pulse must often be lower than the actual pulse repetition frequency.

If proper low frequency response is not obtained the pulse will drop off or tilt, figure 4, because of the inability of the amplifier stages to hold a constant voltage level for the duration of the pulse. This is of importance in our sweep alignment pattern because it is a 60 or 120 cycle pattern with a long flat-top. Poor low frequency response can cause this pattern to fall off alarmingly. Scope response should be very good down to at least 20 cycles. So far as alignment is concerned, scope need not have good high frequency response because of the low repeating rate of the alignment response curve. However, good high frequency response is needed to go trouble hunting in the sync and sweep circuits of the television receiver.

The oscilloscope is particularly helpful in locating the more obscure and hidden defects in the television receiver. It can serve as a critical check instrument so far as waveform shape is concerned and, with proper calibration, can be used to measure pulse amplitudes as well as to permit comparison with manufacturer's values.

c. Input Impedance

The input impedance of your oscilloscope is an important consideration because it gives you a clue as to how much the scope will load any circuit to which it is attached. An oscilloscope is considered to be a high input impedance measuring device and, normally it is, except when checks are made of high impedance circuits or high frequency components are present in the signal to be observed. In television the pulses contain high frequency components and occasionally it is expected that a high impedance circuit must be checked.

If an oscilloscope is said to have an input impedance of 2 megs. shunted by 20 uuf of input capacity it means that the presence of the scope across any circuit adds that value of resistance and that value of capacity in shunt with the circuit. Inasmuch as reactance of capacitive element varies with frequency, the scope will have more of a loading effect at high frequencies because of lesser reactance. For example, figure 5, it can be shown that the amount of loading is also a function of the impedance of the circuit across which it is attached. Across a 25,000 ohm load the scope can reduce this value 30% at the frequency at which the capacitive reactance equals the resistance of the load. This frequency is **only 320Kc.** Thus if a 320Kc. component is present in this circuit its amplitude will be reduced 30% as soon as scope is attached for observation. If this

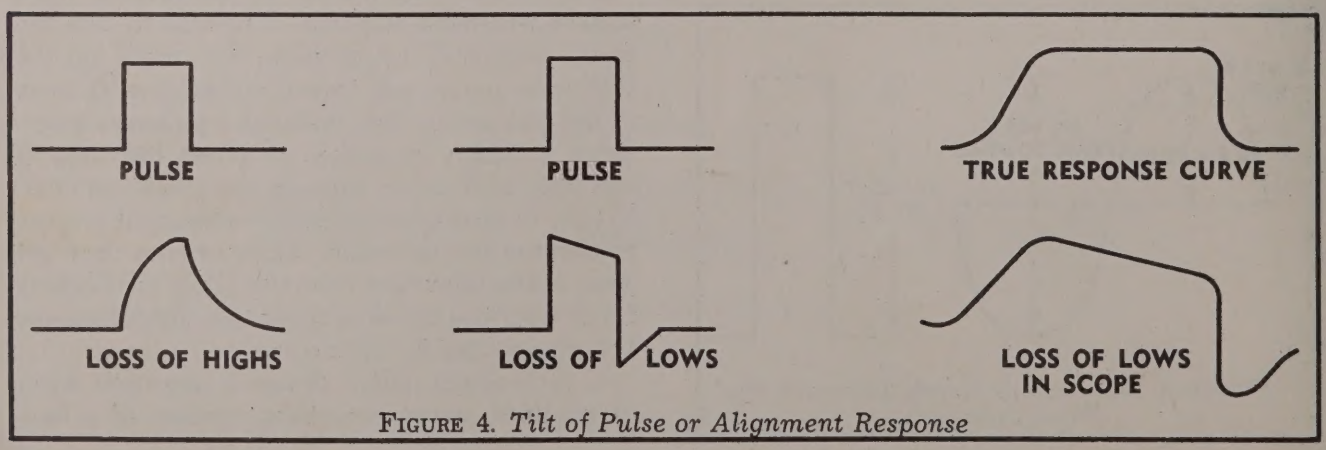


FIGURE 4. *Tilt of Pulse or Alignment Response*

signal is a part of a non-sinusoidal waveform, the loss in amplitude affects the fidelity of the composite waveform; consequently, a true indication is not shown on the screen. Higher frequency components are still more severely attenuated. If scope is connected across a still higher impedance, the circuit loading influence will be more severe. Thus although a scope has a high input resistance in the megohms at low frequencies (audio) this value drops to a very low level because of low capacitive reactance at high frequency. It is very important, therefore, when observing signals and waveforms that contain high frequency components, to attach scope across a low impedance circuit for observation.

If same oscilloscope is attached across a 2000 ohm circuit, figure 5, the 30% loading frequency is higher than 4 megacycles. Thus in observing our television pulse and sweep waveforms there would be no loss in fidelity when checks are made at this point — important frequency components exist up to 1½-2 mcs. and not up to 4. Example demonstrates the need for a scope with a high input impedance (low input capacity) and for making observations at low impedance points in our television receiver.

When scope is attached across a very high impedance circuit and although frequency components might be very low (vertical sweep circuits of television receiver) the resistive part of the input impedance becomes an important consideration. It is a fact that to retain the low frequency components of the vertical sawtooth rather high impedance coupling and time constant circuits must be used (high value grid resistors and low frequency boost circuits). If we attach our scope to the grid of one of our vertical circuits that uses a 2 meg grid resistor the presence of the scope reduces the effective grid resistance to 1 meg. Thus it is again important to attach our scope to a lower impedance point even when checking waveforms that do not contain very high frequency components if utmost waveform fidelity is to be retained.

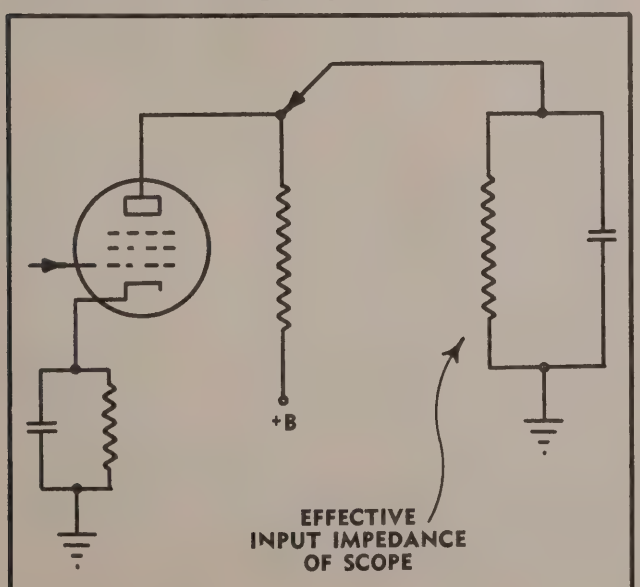


FIGURE 5. *Input Impedance Shunting a Circuit*

A probe is supplied with a scope to permit critical waveform checks. The probe keeps the input impedance as high as possible and consists of a very large resistor shunted by a small capacitor, figure 6, mounted at the free-end of scope cable. Parallel resistor and capacitor are connected in series with inner conductor of shielded cable that carries signal to vertical input of scope. There are three definite advantages to the use of such a probe:

1. Keeps input impedance high
2. Input impedance is a fixed known quantity and no longer a function of lead and ground proximity
3. Stray pick-up is reduced because of shielded probe lead

Although an oscilloscope is said to have a specific frequency response, it does not necessarily mean that you can apply that particular frequency from a circuit and have it appear on the screen unless specific impedance requirements are met first of all. It is true that if a specific frequency is delivered to the input of the vertical amplifier it will get to the screen. However, it is quite easy to lose this signal before it gets as far as the input grid of the vertical amplifier. If it is lost before it reaches this point, the frequency response of the amplifier is of no benefit. Thus if the signal to be observed has high frequency components try to observe it across some low impedance point that will make the input impedance of the scope substantially higher. Under these conditions the entire signal is delivered to the vertical input of the scope and a true likeness will appear on the screen.

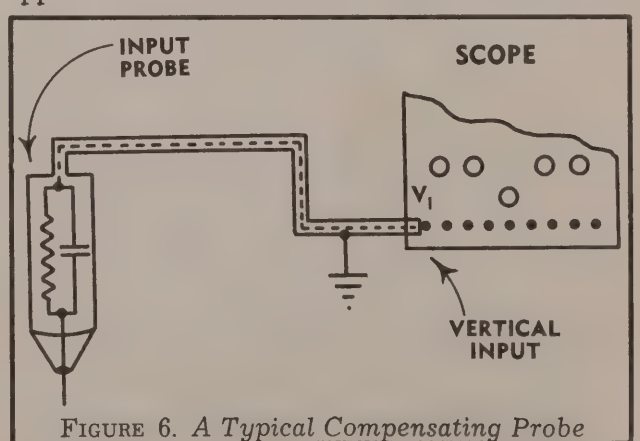


FIGURE 6. *A Typical Compensating Probe*

d. Sweep Range

Frequency range of the horizontal sawtooth oscillator must be satisfactory to permit observation of the television waveforms. Range required is not exacting and most scopes have a wider range than is ordinarily needed for television receiver work. Usually if two lines or more of video information and two complete fields can be presented on screen, sync and sweep circuits can be checked critically. To obtain two lines of video, horizontal sawtooth must operate on a frequency one-half line rate or 7,785 cycles; to see two fields of video information, sawtooth frequency must be 30 cycles. However, for true fidelity these sawtooth waves must be linear so pulses appear on screen in proper relative relation.

e. Sync and Sweep Arrangements

A versatile sync and sweep system is important in a technician's scope. Scope must have a convenient means of choosing either internal or external synchronization or, external or internal sweep. For checking waveform fidelity, an internal sweep along with a good internal synchronization system are needed. Most television sweep oscillators form their own scope sweep and it should be convenient to turn off the internal scope sweep and substitute for it deflection voltage from the sweep oscillator. The strictly FM sweep oscillators are often designed to use the sawtooth sweep internal to the scope but under direct synchronization (external to scope) from the sweep oscillator. Some sweep oscillators can be operated without any connection betwen oscillator and scope if scope has an accurate internally synchronized 60 cycle sine sweep. It should be possible to choose any one of these modes of operation with ease.

Some important sync and sweep features are:

1. Tight synchronization of internal sweep
2. Internal sweep and external synchronization
3. External sweep and internal oscillator off
4. A wide range phase shifter to permit shifting phase of internal sweep to make alignment curves overlap
5. Internally generated and synchronized 60 cycle sine wave with means of phasing
6. Beam blanking circuit to remove retrace whether it be an alignment retrace or sawtooth retrace
7. Switching arrangement to permit observation of alignment curves and waveforms in upright position

f. Crystal Probe

A very helpful accessory to use with a scope is a crystal probe, figure 7. It can be used to rectify an r.f. or i.f. signal and presents whatever modulation is present to the vertical input of the scope. If vertical amplifier has proper wide range frequency response this modulation can be video, 400 cycle tone, or sweep response curve.

Thus in addition to signal tracing, the response pattern of individual stages or specific groups of stages can be readily observed.

g. Angle of Attack

Do you know the characteristics and features of your scope? Learn them to be able to make full use of your scope and to take some of the guesswork and indecision out of your job. Know what can be done with your scope and the accurate and best way of doing each job.

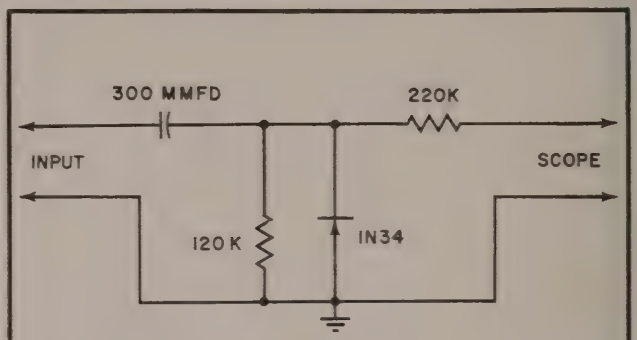


FIGURE 7. *Crystal Probe Schematic*

KNOW YOUR SCOPE

Your first duty after you have purchased a new test instrument is to become familiar with the controls and functions and, what can or can not be done with the instrument. Learn exactly what each control does and logic for each switch position.

With this in mind we have set-up a sequential procedure check for you to follow to teach you the functions of the scope operating controls and exactly what can be done with each. Do it and become completely familiar with your scope.

In this procedure a Triplett, figure 8, scope will be used as a typical example. There are no great variations in panel symbolization between manufacturers — so no matter what type scope you have purchased follow along with the sequence with help of your scope instruction manual.

1. Set-SWEEP RANGE on 10-60 position and SWEEP VERNIER full clockwise. Put SYNC HORIZ SWEEP SEL on INT.

2. Turn scope on and raise brightness with INTENSITY control. Adjust FOCUS until line is

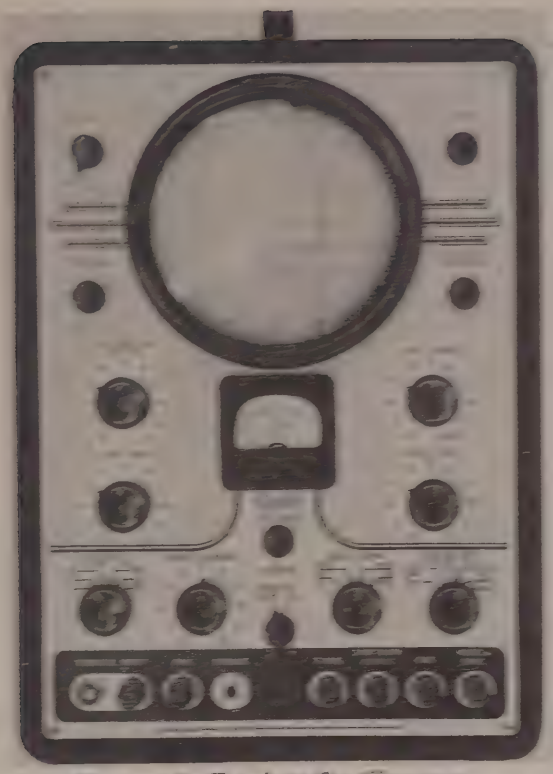


Figure 8. Triplett Oscilloscope

sharp and distinct. Use VERTICAL CENTERING to center trace on center line of screen chart.

3. Adjust HORIZ GAIN until line is approximately four inches long. Use HORIZONTAL CENTERING to center with respect to vertical center line of scope chart.

4. Connect cable to VERT input and attach to 6.3 volt AC source. Set VERTICAL ATTEN CAL on 10 position and adjust VERT GAIN until vertical deflection occupies six major divisions on screen. Try each position of attenuator and observe results, coming back to 10 position.

5. Set SYNC SIGNAL control full counter-clockwise. Adjust SWEEP VERNIER until single sine wave is gotten. Now advance SYNC SIGNAL until sine wave just locks firmly. Turn SWEEP VERNIER counter-clockwise until two sine waves appear on screen (sawtooth frequency now 30 cycles). Turn back to single sine wave. Set VERTICAL GAIN until sine fits exactly within six divisions.

6. Turn VERTICAL ATTEN CAL to CAL 3V position. This applies a comparing sine wave into vertical amplifier. DO NOT TOUCH VERTICAL GAIN CONTROL SETTING. Advance CALIBRATING VOLTAGE until sine wave occupies same six divisions as first sine wave signal. Notice meter reads approximately 1.77 volts. Attenuator had previously been set on 10 (step 4) so applied voltage is 10 times 1.77 reading or 17.7 peak-to-peak volts. RMS value is of course 17.7 divided by 2.82 or 6.3 volts RMS as it should be. Always remember to multiply meter reading by attenuator factor (setting used when signal to be measured was set-up) when making voltage measurements. Set VERTICAL ATTEN CAL back to 10 position. If your scope does not have an internal voltage calibrator, refer to section on construction and use of external voltage calibrator.

7. Flip NORM REV switch and observe action on waveform. Put SYNC HORIZ SWEEP SEL switch on LINE. Notice sine pattern remains. On this position scope sawtooth oscillator is being synchronized by an internal 60 cycle source and not by any part of the incoming signal. If applied signal were other than a 60 cycle or multiple of 60 cycle signal it would not lock in.

8. Set SYNC HORIZ SWEEP SEL to EXT position. Notice that pattern soon begins to wander off. On this position external sync has to be applied via SYNC input connectors to lock pattern on screen.

9. Set SYNC HORIZ SWEEP SEL on phased 60 cycle position. On this position a sine wave sweep is being used. Vary PHASING control and notice influence on pattern. At specific settings of phasing control a line or circular pattern will result showing a change in the phase relation between the vertical and horizontal sine waves between in-phase and 90 degree relation. This control is used to phase alignment patterns, so near to exact overlap is obtained.

10. Set SYNC HORIZ SWEEP SEL to HORIZ INPUT position. Notice horizontal sweep is lost and only a vertical line appears on screen. Now apply 60 cycle 6.3 volt source to HORIZ input and once again a horizontal sweep starts. Turn SYNC SIGNAL control full counter-clockwise until you feel switch snap. In this position retrace is blanked. This special blanking position can be used to eliminate alignment retrace when SYNC HORIZ SWEEP SEL is either in HORIZ INPUT or 60 cycle positions. On other positions blanking elimination is automatic and SYNC SIGNAL control is operated normally.

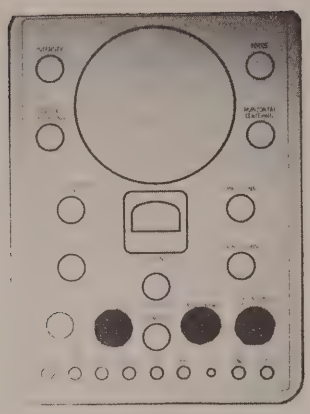
11. Signal in vertical amplifier of scope can be heard by plugging headset into PHONES jack. Modulation can be applied to grid of cathode-ray tube via Z-AXIS input.

IMPORTANT SWEEP GENERATOR CHARACTERISTICS

These are factors, figure 10, of importance to know about your sweep generator:

1. Frequency Ranges
2. Output Levels and Impedance
3. Sweep Width Deviation
4. Marker Facilities
5. Special Features

FIGURE 9. *Oscilloscope Operation*



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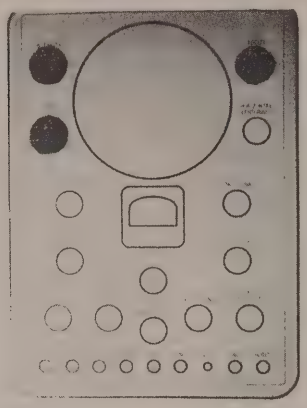

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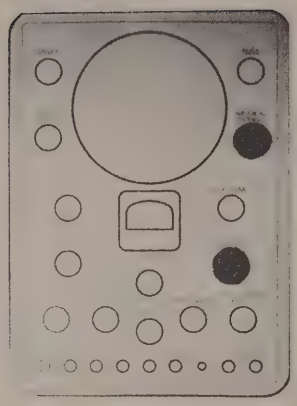

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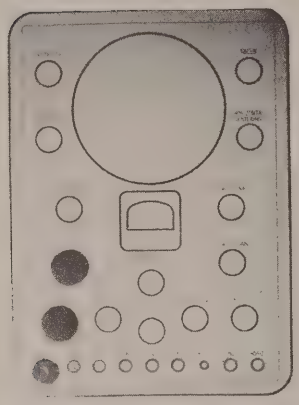

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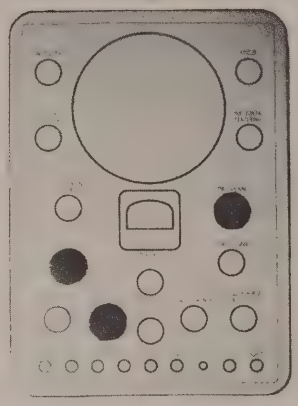

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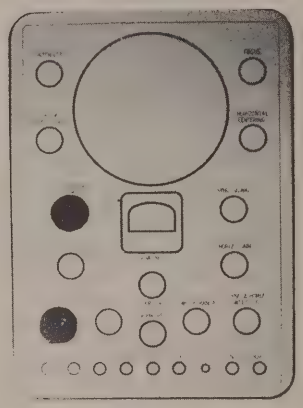

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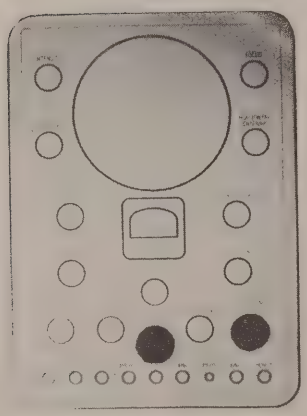

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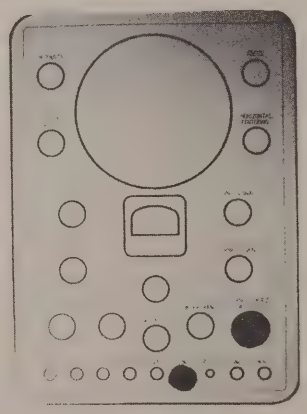

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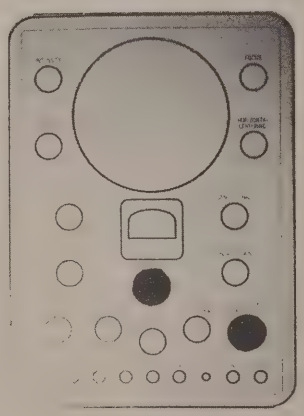

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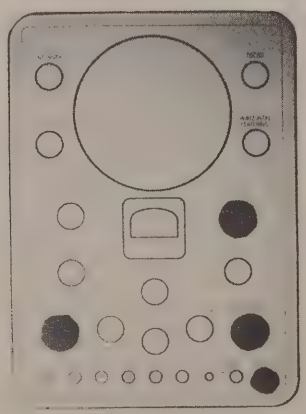

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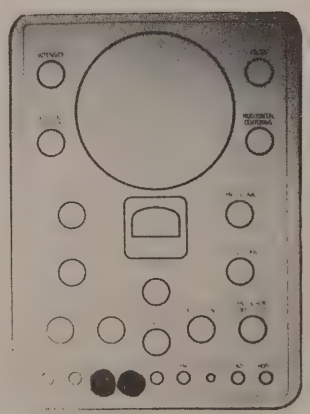

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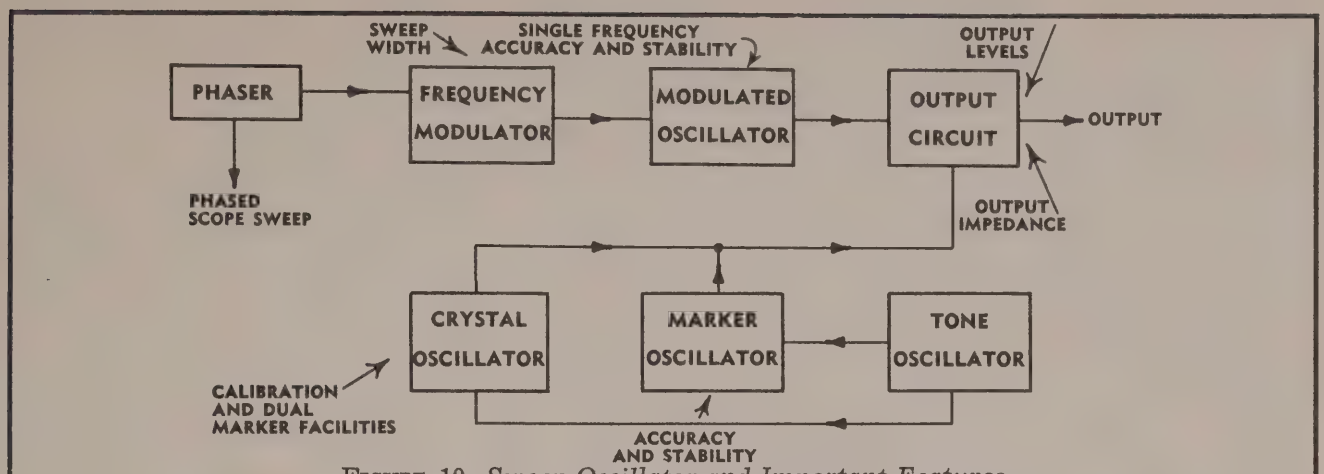


FIGURE 10. *Sweep Oscillator and Important Features*

a. Frequency Ranges

Frequency ranges of sweep generator and marker must be adequate to cover the entire span of television and FM frequencies. Both i-f and r-f ranges must be available, preferably as an oscillator fundamental frequency. It should be possible to obtain a good reliable single frequency in the r-f ranges as well as the i-f span of frequencies used for marker work on the i-f response curve. A controlled sweep frequency output must be available in the r-f and i-f ranges.

Though a television combination, it would be convenient to be able to use unit as a single frequency generator (with 400 cycle AM modulation facilities) over the AM-FM-TV frequency ranges needed in the alignment of all types of home receivers. Output should be stable and calibration accurate. Special crystal control facilities should be available to permit occasional frequency and stability checks on generator.

These complete facilities in one or at most two units reduce grounding problems and provide a simple, compact, and effective bench arrangement. The number of inter-connections and necessary leads are reduced, saving time and minimizing feedback and grounding difficulties.

b. Output Levels and Impedance

High and low output levels are needed from generator in TV receiver alignment. When an overall alignment check is to be made or response pattern of a great many stages obtained, a low level output is needed from generator to prevent overloading amplifier and consequent incorrect response. Inasmuch as resonant conditions in a wideband television amplifier are a function of AGC action or setting of contrast control (Miller effect) it is preferable to align at weak or low level amplitudes for peak receiver performance. To do so means output of sweep generator must be kept at a conservative level. Good control of output level is therefore important and stray radiation should be a very minimum to prevent indirect feed into amplifier under check from overloading or distorting response curve. A good ground system is of utmost importance.

If a single I-F stage is to be aligned (particularly if it is a low-gain wideband stage) sweep output level must be high if sufficient signal is to be made available for oscilloscope vertical input. Maximum output level should be at least 0.5 volts RMS.

Output impedance should be such as to provide proper matching to a low impedance input circuit and low enough to prevent capacitive losses when a high impedance circuit is being fed. What is more important a choice of balanced or unbalanced feed should be available. This is an important need in tuner alignment because both balanced and unbalanced antenna input circuits are used, figure 10.

c. Sweep Width Deviation

There must be ample sweep range and good control over it. Sweep should deviate an equal span on each side of center frequency set up on calibrated frequency dial. It should be possible to obtain with ease and reliability a very wideband deviation or a narrow sweep width. For the wideband r-f and video i-f stages a maximum width of 10 to 12 megacycles (5 to 6 megacycles on each side of center frequency) should be obtainable. At the same time it should be possible to narrow the sweep width very sharply to take care of sound i-f strips and discriminators — no more than 200 kilocycle sweep width.

d. Marker Generator and Facilities

An accurate marker system, preferably built-in, is essential if you are to rely on your service procedures. Certainly, accuracy of generator and calibration is very important in the spot fre-

quency alignment of individual tuned circuits and wavetraps in standard TV receivers. It is essential that you can rely on your marker generator. Marker amplitude must be controllable over a wide range depending on whether marker is to be used as a single frequency generator for spot frequency alignment (high output level required) or as a response pattern calibration (low level to prevent distortion of pattern).

An absorption as well as an oscillating marker is helpful. The oscillating marker or "pip" marker is generally used because of its sharpness and strength. However, on occasion, spurious beats are set up between marker oscillator and other signal sources and more than one marker appears on response pattern. A strictly absorption marker (resonant circuit only) can then be used to produce a "dip" marker on the response pattern immediately over the true "pip" marker. No dip will appear over false markers put on pattern by spurious beats.

e. Special Features

Sweep alignment equipment should include an oscillator that can be crystal controlled (preferably one separate from the tunable marker oscillator) to permit use as an accurate marker and for occasional checking and calibration of the tunable oscillators of the sweep generator. If crystal oscillator is separate from marker oscillator a dual marker can be placed on response curve.

A wide range phasing system is necessary so alignment patterns can be properly phased on scope screen when sweep oscillator is supplying horizontal deflection for the alignment scope.

KNOW YOUR SWEEP GENERATOR

It is one thing to know the features of your sweep generator; another, to be able to take full advantage of your sweep generator. To know your sweep generator thoroughly go through succeeding alignment checks on a TV chassis. There are three basic methods of interconnecting sweep oscillator, scope, and amplifier under test to obtain a response pattern. To become completely familiar with your sweep, choose an amplifier known to be in good operating condition and try each basic interconnection method, figure 11, as follows:

a. Phased 60 Cycle Sine Method

In the phased 60 cycle method the horizontal sweep of the scope is an internally generated sine wave. The phase of this sine wave can be adjusted to make it conform with the sine wave that frequency modulates the sweep oscillator. With this method only two equipment interconnections are needed — between sweep oscillator output and amplifier under check and between amplifier output and scope input.

b. Sweep Alignment Precautions

In all sweep alignments a number of factors must be considered. When it comes to a sweep alignment of a specific model do follow manufacturers' procedures — don't guess and surmise.

a. Ground System — We can not overemphasize the importance of a good ground system. If ground system is indefinite, response pattern is indefinite too. Work on a grounded bench (with proper a.c. isolation transformer for transformerless supplies) or preferably mount test equipment on a metal shelf with a short ground strap that can be attached to any chassis under check. Shelf or bench must be in turn grounded (such as water pipe system, etc.). A good ground system will give your equipment an opportunity to show you the true response of any unit under check.

b. Bias and Level Considerations — A true response pattern is obtained when signal levels in the amplifier under check are held normal. If stages are operated at improper bias levels resonant frequencies are shifted by Miller effect and response pattern distorted. If stages are overdriven with too much signal either pattern is flattened or bias voltages shifted. Methods of setting bias and levels vary from manufacturer to manufacturer but involve one or more of the following stipulations:

1. Apply an external or controlled internal voltage to bias lines to set up correct operating conditions.
2. Set contrast and gain for normal bias and levels.
3. Keep input signal at normal level by direct measurement or by evaluating strength of signal at ouput of unit under check.

c. Interference Rejection — A number of recommendations are often made to prevent introduction of spurious signals that might confuse or distort response pattern:

1. Shunt point at which signal is removed for application to vertical input of scope with a 1000 to 5000 uuf capacitor. This capacitor shunted to ground kills interference but does not shunt low frequency 60 or 120 cycle response output.
2. A good ground system minimizes spurious signal pick up, particularly the 60 cycle hum variety that can displace trace and retrace vertically on scope screen.
3. Removal of local oscillator tube to prevent spurious beats.

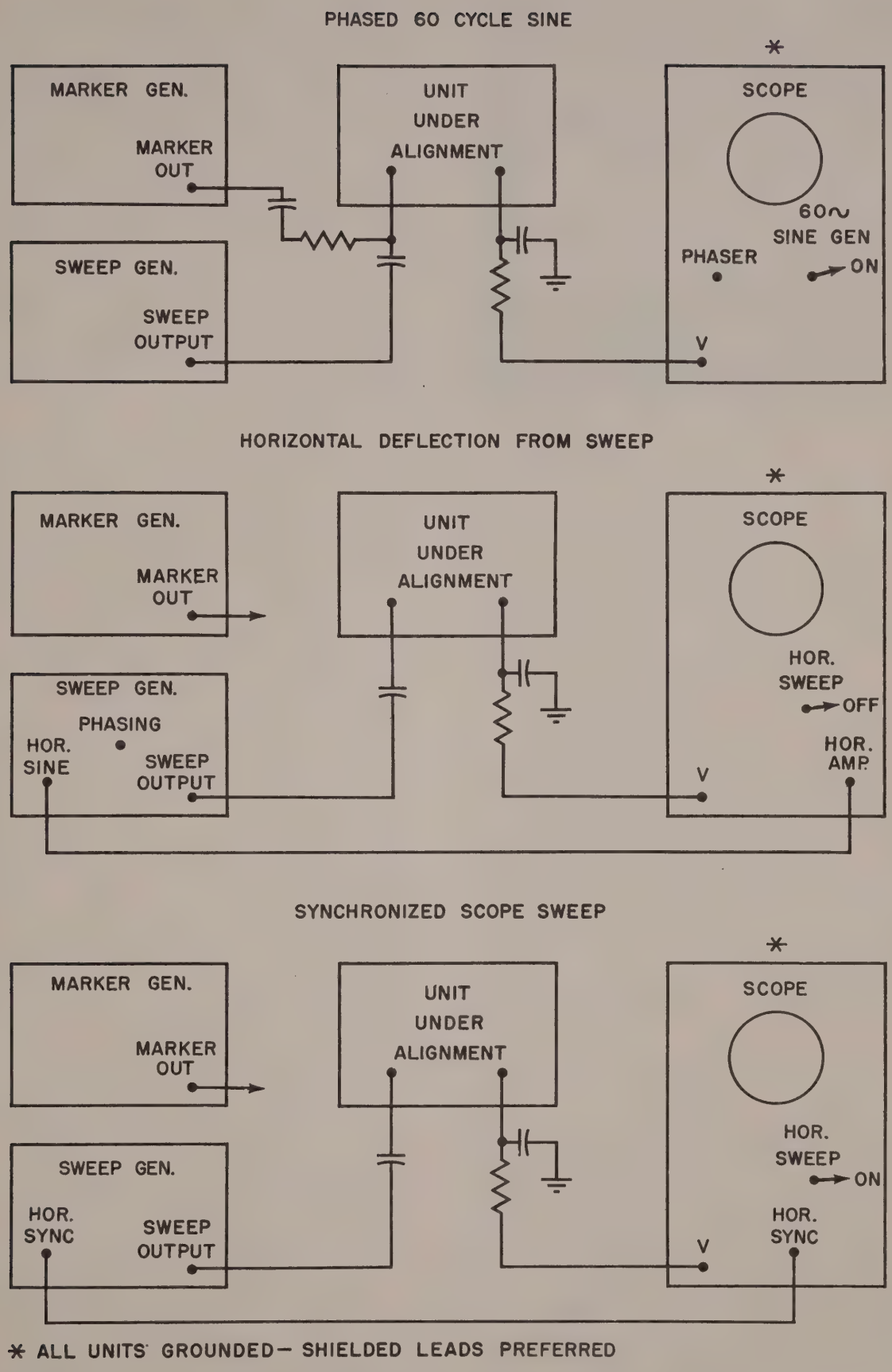


FIGURE 11. *Alignment Interconnection Methods*

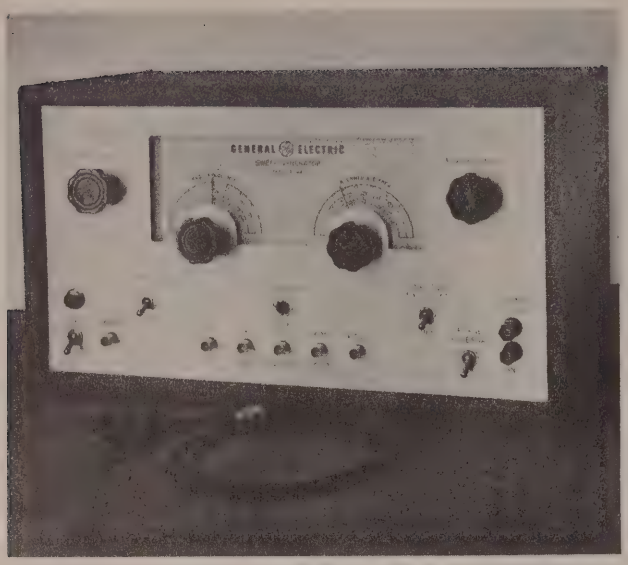


FIGURE 12. *General Electric Sweep Oscillator*

FIGURE 13. *RCA Signal Calibrator*

4. Removal of horizontal and/or vertical oscillator tubes to prevent pick up of transient signals.

c. Familiarization Procedure

In the familiarization procedure that follows a sweep generator, an RCA calibrator, and a Triplett scope are used. There is sufficient symbolization uniformity and likeness in operation between manufacturers' types to permit you to follow along with whatever types of equipments you use or have just purchased. The important thing is — do it. Much is learned by taking on your shoulders the sole responsibility of doing and attempting to learn thoroughly the operation and utility of the test units with which you must work. Resolve to start beating the problem now by setting up your test equipment and following along with the procedures presented in step-by-step sequence throughout this manual.

In first sequence, scope must have internal 60 cycle sine wave sweep. If it does not start with procedure d.

1. Connect SWEEP OUTPUT of sweep generator to mixer in accordance with recommendations of manufacturer.

Note: Typical points of connection are grid of mixer, mixer shield (after it is released from ground), antenna input, or grid of first i-f amplifier. When direct connection is made (such as grid of mixer) use a 1500 to 3000 uuf capacitor in series with sweep oscillator lead to prevent shunting of bias or other receiver d.c. lines.

2. Connect output of amplifier under check (video detector) to VERT input of scope. Shunt 3000 uuf capacitor to ground at output. This permits you to obtain a clean pattern. For better isolation, scope is often attached to output through a 10K series resistor.

3. Set INTENSITY and FOCUS controls properly. Adjust oscilloscope CENTERING and HORIZ. GAIN controls to center horizontal line gotten when SYNC & HORIZ. SWEEP SEL is set on PHASED 60 cycle position.

4. Set SWEEP FREQ. BAND SELECTOR on 23 megacycles. Set SWEEP WIDTH near maximum.

5. Adjust PHASING control on scope until trace and retrace lines overlap. Readjust INTENSITY and FOCUS controls for clean pattern.

6. Adjust COARSE and FINE ATTENUATION controls of sweep oscillator in conjunction with VERTICAL ATTEN. & CAL and VERT. GAIN controls of scope to seek weakest signal from sweep oscillator that will produce a usable pattern on scope screen — least attenuation at scope; most attenuation of sweep oscillator output.

7. Marker signal is added to sweep signal in a number of different ways:

A. Internal marker insertion is used for most arrangements that use a built-in marker generator. Generally, a switch permits addition of marker signal when desired.

B. When marker generator is separate from sweep generator the marker signal can be applied at any convenient point — at same point as sweep signal or at a separate point. Follow recommendations presented in alignment instructions per given receiver. The most important consideration is to prevent signal insertion from loading response curve or changing operation conditions of unit under alignment. To minimize influence of

marker, keep marker amplitude down and apply signal through a series blocking capacitor (1000 uuf) and resistor (10,000 ohms). In case of very weak marker level it is at times necessary to remove or reduce value of series resistor to obtain a discernible marker.

C. In some sweep generator-marker generator arrangements the output of sweep generator is patched into and through external marker generator. Combined sweep and marker output of marker generator is then applied to unit under alignment.

8. Set marker generator or signal calibrator frequency on approximately 23 megacycles. Turn up MARKER OUTPUT until marker appears on response curve. Turn up MARKER OUTPUT and notice how it distorts pattern when level is too high. Back off until marker is just visible and not distorting pattern. Rotate MARKER FREQUENCY control observing how marker sweeps across the pattern. Calibrate marker generator frequency as per instructions given in "How to Calibrate Sweep and Marker Generators."

9. Detach vertical input cable of scope and attach in its stead the crystal probe cable. Touch probe to successive grids of the amplifier under check. Readjust VERT. GAIN and attenuator if necessary to retain pattern. Notice that with crystal probe, response of an individual stage or specific groups of stages can be obtained. Detach crystal probe and replace with standard input cable.

d. Horizontal Deflection From Sweep Generator

In this interconnection method a sine wave generated in the sweep generator is used as horizontal deflection voltage for the scope. Scope internal sweep is turned off.

10. Interconnect units as per steps 1 and 2. In addition connect cable between HORIZONTAL output of sweep oscillator and HORIZ-GND input of scope. This expedient conveys deflection sine wave between sweep oscillator and scope.

11. Switch SYNC & HORIZ. SWEEP SEL to HORIZ. INPUT position. This turns off internal sweep and opens circuit to external sweep.

12. Adjust sweep oscillator PHASING CONTROL until patterns overlap. Notice with this method of interconnection, phasing is controlled from sweep oscillator source of deflection voltage.

13. Repeat steps 4 through 9.

e. Synchronized Scope Sweep Method

In this method of interconnecting equipment, synchronization is supplied from sync-horizontal output of sweep oscillator to **sync input** of scope. Internally generated sawtooth of scope is now to be used as horizontal deflection but sawtooth generator is synchronized by signal from sweep oscillator.

14. Interconnect units as per steps 1 and 2. In addition connect cable between HORIZONTAL output of sweep oscillator and SYNC-GND input of scope. Connection supplies external sync to the oscilloscope.

15. Set SYNC & HORIZ. SWEEP SEL on EXT. In this position internal sawtooth sweep is turned on with facility for external synchronization. Set SWEEP RANGE on **60.**

16. Turn up SYNC SIGNAL about half-way. Adjust SWEEP VERNIER until single response pattern locks in.

17. Adjust sweep oscillator PHASING CONTROL and oscilloscope HORIZ. GAIN control until response pattern is spread over major portion of screen.

18. Repeat steps 4 through 9.

IMPORTANT VACUUM TUBE VOLTMETER CHARACTERISTICS

These are factors of importance to know about your vacuum tube voltmeter:

1. Measurement Ranges and Accuracy
2. Frequency Ranges
3. Input Impedance
4. Sensitivity
5. Special Features

a. Measurement Ranges and Accuracy

Meter ranges must be wide enough to permit measurements over the range of voltages found in the television receiver — a.c. and d.c. with picture tube high voltage a possible exception. The d-c scale should permit measurement of the very low bias voltages to the high d.c. voltages that must be used in the deflection circuits. The a-c scale must accommodate the peak amplitudes of the sweep waveforms as well as the low level signals found across the video detector or discriminator outputs.

The resistance ranges should permit measurements of the very low value resistors found in a television receiver up to the very high ones used in the deflection and high voltage circuits (up to hundreds of megohms).

b. Frequency Ranges

Frequency range of meter should be broad enough to permit readings on all signal frequencies that are present in the television receiver. It should be possible to measure approximate peak amplitudes of the various non-sinusoidal waveforms present in the sync and deflection systems of the television receivers. It should be possible to measure the r.f. and i.f. signals present in those

sections of an operating receiver. Thus the frequency range of the meter must extend up to at least 200 megacycles.

c. Input Impedance

So far as loading is concerned, when using the vacuum tube voltmeter, observe the very same cautions you would in the use of an oscilloscope (as discussed in detail in the section of this manual on the characteristics of the scope). When measuring high frequency signals attempt to obtain the readings across a low impedance for better accuracy.

So far as d-c measurements are concerned the input resistance of the usual VTVM is extremely high and very little loading results. However in a-c measurements two additional factors influence loading — namely, input capacity and transit time. Input capacity of instrument has the same influence on circuits as the input capacity of a scope, influencing operation of circuit and accuracy of measurements if loading is too severe (refer again to discussion of input capacity in scope section of manual). Transit time does not have a serious influence on loading until frequency is up in the megacycles; at least, loading on the general types of television circuits does not become severe over the video range. A good meter therefore can be used to check frequency response of a video amplifier.

Loading can be quite severe on the higher impedance i.f. and r.f. circuits. If accuracy is important, choose a low impedance circuit to minimize influence of input capacity (can shift frequency of resonant circuits) and resistive loading (can change bandwidth and lower signal levels).

Input capacity of meter should be held under 10 uuf. Even this value can seriously change frequency of low C resonant circuits, changing levels and response. Resistive loading can become more severe the higher the frequency to be measured — a half megohm and higher at frequencies lower than one megacycle, dropping below 100K at frequencies higher than 10 megacycles, and under 1000 ohms above 50 megacycles. It is very important to realize that although a meter might have a linear response up into the hundreds of megacycles it can only so respond if the circuit under measurement is not loaded by input impedance and altered in its manner of operation.

d. Sensitivity

Another important characteristic of a meter is its sensitivity and range scales; choice of instrument, again, is dependent on what measurements are to be made. If weak radio-frequency signals are to be measured, the instrument must be extremely sensitive. This is an important consideration when meter is to be used for alignment purposes and measurement of received signals. Meter should have at least a 0-3 volt seale and preferably a 0-1 volt scale.

e. Special Features

Some of the features that a meter could have to expedite work on television receivers are zero center d-c scale for discriminator alignment and bias voltage measurements and a minimum number of test leads to permit speed and facility. Meter should be well protected to prevent damage in transit and must not be bulky. Operation should be simple and direct.

KNOW YOUR VTVM

The vacuum tube voltmeter can be used to measure d.c. and a.c. voltages in a television receiver with a minimum loading and high accuracy. Radio frequency voltages can be measured with accuracy if probe can be attached to a point where it does not load circuit being measured. Loading is most severe across a high impedance, very high frequency source and across high frequency resonant circuits.

A Sylvania Polymeter, figure 14, is used as a typical example of a versatile VTVM for the service shop.

1. Attach cables correctly to meter panel depending on type measurements to be made.

2. Set RANGE switch on proper range and measure d.c. voltage output of a small power

FIGURE 14. *Sylvania VTVM*

supply. Notice influence of —V and +V positions of SELECTOR switch.

3. Set SELECTOR and RANGE switches to measure 6.3 volt filament source. Use ZERO SET for peak accuracy.

4. Set SELECTOR on R.F. Volts and RANGE on 0-3 volt position. Measure output of sweep or marker generators (generator set for maximum output) from 10mcs. to 200 mcs.

5. Set SELECTOR on OHMS position and adjust OHMS SET for proper full scale deflection. Short leads together and set ZERO SET for zero. Measure various values of resistors using a number of scales.

6. To use center-scale for discriminator alignment, vary ZERO SET until meter pointer coincides with center zero with SELECTOR set on a.c. position.

7. If VTVM has peak-reading facilities and scale, compare normal a.c. scale with peak reading scale when measuring a 6.3 volt source. Peak scale should read approximately 8.9 volts (1.414 times 6.3).

8. If pulse source is available (television signal in video amplifier of operating receiver) measure peak voltage and record. Reverse leads and take second reading. Actual peak voltage is sum of two readings.

VOLT-OHM-MIL METER IN TELEVISION

A good volt-ohm-mil meter is an important tester in television and radio repair work. It perhaps can be called the basic service test tool. A technician with a good technical sense needs only his knowledge and this simple type of meter to locate many troubles in a television receiver. In fact, the more elaborate test equipments are most often needed to locate the more obscure and difficult troubles, and to assist in critical adjustment and alignment work. Even when a difficult trouble has been isolated with the more elaborate test units it can often be the volt-ohm-mil meter that hunts out the defective part.

The volt-ohm-mil meter is the ideal type to take out on the job because it is durable and lightweight. It can be used to make basic voltage and resistance measurements as well as specific tune-up voltage checks recommended for some models. A high voltage probe for your volt-ohm-mil meter is important because high voltage ailments are very common in TV receivers.

a. Sensitivity: The meter, of course, should have adequate ranges as discussed in conjunction

FIGURE 15. *Triplett Volt-Ohm-Mil Meter*

with VTVM. Sensitivity should be at least 20,000 ohms per volt on D.C. and 5000 ohms per volt on A.C. Without a high sensitivity, the readings across high resistance circuits (relatively low current stages) will be in error because of loading and current required to operate the meter. Another advantage of a sensitive instrument is the extended ohms range possible in a portable instrument. More battery is required to operate an equivalent ohms range with a meter of lower sensitivity.

b. Accuracy and Convenience: An overall accuracy of ±3% on D.C. scale is considered sufficient and has been almost an industry standard. A.C. accuracy is usually ±5%. It is important that components within the instrument be of sufficient stability to retain this accuracy. Be certain the volt-ohm-mil meter you select has good stable resistors and operating conditions.

The volt-ohm-mil meter is the portable work horse in electronic servicing. Therefore ease and speed of operation along with reliability are factors of significance. Speed of operation is improved with a large easy-to-turn range switch and minimum changing of test leads required for various types of measurements.

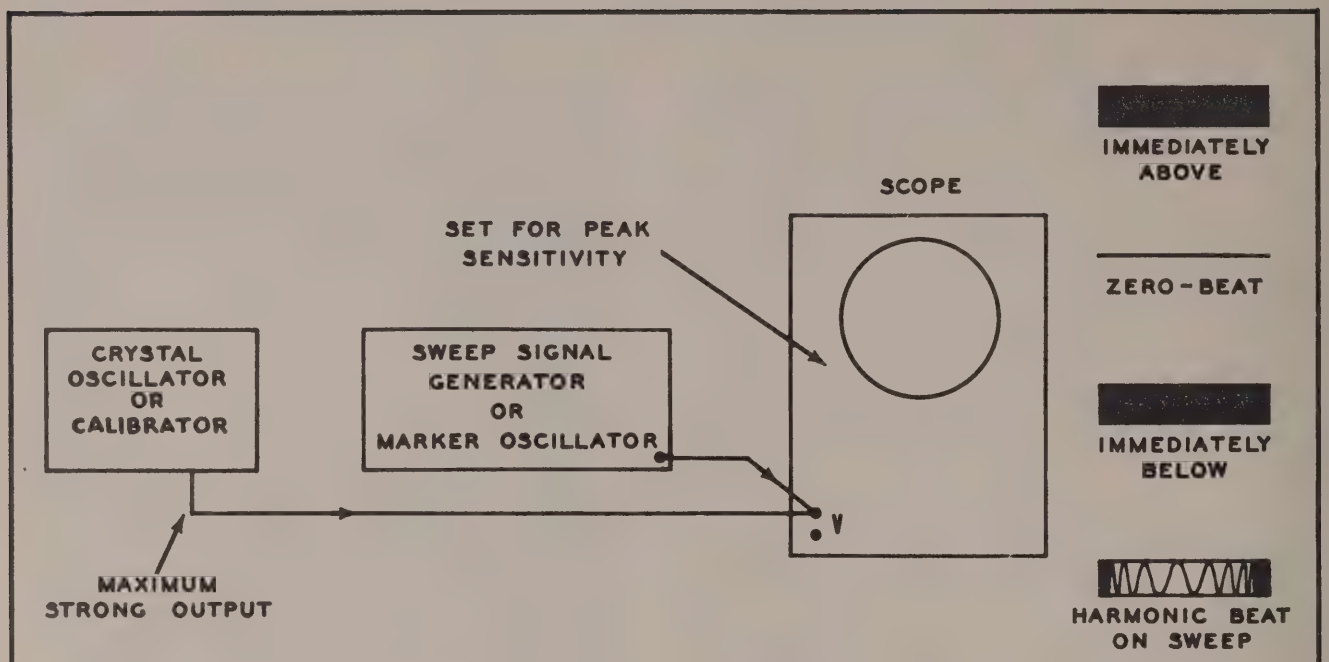


FIGURE 16. *Calibration of Marker or Sweep Signal Generator*

ALIGNMENT METHODS

WE CAN NOT OVEREMPHASIZE THE IMPORTANCE OF "LEARNING BY DOING." THE FOLLOWING ALIGNMENT PROCEDURES WILL BE APPLIED TO A SPECIFIC BUT VERY COMMON TYPE OF CHASSIS. IF THIS TYPE OF CHASSIS IS AVAILABLE TO YOU, DON'T JUST READ THESE PROCEDURES BUT SET UP YOUR TEST EQUIPMENT AND FOLLOW RIGHT ALONG WITH THE PROCEDURES. IF YOU DO NOT HAVE IDENTICAL RECEIVER, DISCUSSIONS ARE GENERAL ENOUGH THAT YOU CAN SET UP WHAT YOU HAVE AVAILABLE AND WITH HELP OF INSTRUCTION MANUAL FOR YOUR PARTICULAR CHASSIS FOLLOW ALONG WITH US. THE IMPORTANT THING IS "TO DO IT" AND DO IT YOURSELF.

Sweep oscillator, scope, and VTVM are used for numerous television receiver alignment tasks. To demonstrate practical applications of test instruments the procedures will be coordinated to a standard receiver chassis. Alignment steps as recommended by RCA for their chassis will be followed. We do this to emphasize three extremely important bits of advice:

A. PROPERLY INTERCONNECT EQUIPMENT
B. FOLLOW MANUFACTURER'S PROCEDURES
C. CALIBRATE SWEEP SIGNAL GENERATOR

(refer to "Know Your Sweep Oscillator," page 14)

Countless receivers are improperly aligned because these basic rules are ignored. As a result, the receivers are returned to customers with fuzzy pictures and subject to interference.

Procedures are written under assumption that the general operation of the test equipment is known and understood. **If not, refer to sections "Know Your Scope," "Know Your Sweep Oscillator" and "Know Your VTVM." Study in particular the alignment instructions given under "Know Your Sweep Oscillator."**

An effective order of alignment as recommended by RCA for their chassis is sound discriminator, sound i.f., picture i.f. traps, video i.f., r.f. amplifier and mixer, and local oscillator. To learn more about how to handle your test units study these procedures carefully — the same basic ideas are used in the alignment of any TV receiver.

a. Calibration of Signal Generators

The many critical spot frequencies required in the alignment of a TV receiver requires an accurately calibrated frequency source such as signal calibrator or crystal marker generator. We can not overemphasize the importance of accurate calibration of marker and sweep signal generator. In fact accurate calibration can be accomplished with just one or two well-chosen crystal frequencies. An external crystal oscillator or crystal calibrated signal calibrator can be used or, as incorporated in some sweep signal generators, an internal crystal oscillator that operates separately from the marker oscillator. If a great amount of tuner work is done there is nothing so helpful

as a group of crystals that supply markers for picture and sound carriers of each channel or, at least, sound carrier of each channel. With sound carrier marker appearing on response curve, variable marker can be made to overlap it and then moved exactly 4½ megacycles lower to supply picture carrier marker. In areas with only one or two stations, crystals can be purchased for those channels.

Calibration of test unit can be done simply, using only a scope:

1. Apply marker generator and calibrator output to vertical input of scope, figure 16.

2. Turn up outputs to maximum. Adjust scope vertical amplifier and attenuator for peak sensitivity.

3. Set frequency of marker generator near crystal frequency or correct harmonic. As marker generator frequency is brought near calibrator frequency a beat pattern will appear on scope screen. Pattern will swell then fall suddenly to minimum or zero. As frequency continues to be varied in same direction pattern will again swell. The dip between the two swells represents a zero beat and indicates setting at which marker oscillator and crystal oscillator are on same frequency.

4. So far as marker generator calibration is concerned two helpful crystal frequencies would be at each end of i.f. spectrum. For example crystals for picture carrier of 25.75 mcs. and sound carrier of 21.25 mcs. would not only permit you to calibrate your marker generator at each end of the i.f. range but the crystals could be used to put carrier markers on the i.f. response curves. A dual marker arrangement is then possible using your regular variable marker as a running marker on your response curve. These same crystals can be used to calibrate your sweep signal generator on its i.f. ranges as per steps 1 through 3. Also the crystal harmonics can help you to calibrate the channel ranges of your sweep signal generator.

The 21.25 mc. crystal would have a harmonic (third) on 63.75 megacycles to check low end of low band; a fourth harmonic on 85 mcs. to check calibration or act as marker at high end of low band. For high band checks, harmonics are available at 170 megacycles (eighth) and at 212.5 mcs. (tenth). It is interesting to note that a 21.25 mc. crystal puts a harmonic very near the center of channels 3 and 6 and just below channel 10 — the three channels allocated in the Philadelphia area. Such a convenient combination may be available in your area.

5. Sweep signal generator can be checked by applying its output along with that of calibrator to vertical input of scope. Set sweep width for a moderate deviation. When checking sweep signal generator against a high harmonic of the crystal a strong beat is not obtained. Instead as center frequency of generator is brought near crystal frequency sine waves will appear as per figure 16. When longest wave-length sine wave appears at center of trace the center frequency of sweep signal generator matches harmonic of crystal.

6. Inasmuch as beat pattern is result of some non-linear mixing, the pattern is often weak particularly when calibrating at r.f. ranges. Use of a crystal probe with scope permits a stronger beat pattern.

7. If there is any calibration inaccuracy make a record of the differential so it can be used when setting marker or sweep generators on a specific frequency.

8. Marker generator can of course be also calibrated on a sweep response curve. This can be done by changing marker generator frequency until its mark on the response curve coincides with a calibrating marker put on the same response curve with a signal calibrator or external crystal oscillator.

b. Sound Discriminator Alignment

To derive full benefit from these procedures, set up your alignment equipment and follow along. An RCA 8TS30 was chosen as a demonstration chassis because this very same chassis or a very similar one can be found in most every service shop or television school in the country. Follow the alignment using the schematic of figure 18 if you have an identical chassis or, locate identical points on whichever 630 type chassis and schematic you are using.

In the alignment of the discriminator, RCA first suggests the spot frequency alignment of the two resonant circuits of the discriminator transformer using a signal generator and VTVM. Second, a response check is made with sweep oscillator and scope. Final touch-up is made with regard to linearity and center frequency.

1. Connect output of signal generator through a series capacitor (1000 uuf) to grid of third sound i.f. stage. Set the signal generator on 21.25 mcs. and adjust output to 0.1 volt level (measure voltage at grid with r.f. VTVM). This precaution prevents overload.

2. Connect VTVM in series with 1 megohm resistor to the junction of diode resistors R219 and R220. Do not remove discriminator shield to make this connection but make connection to transformer lug C through the hole provided for

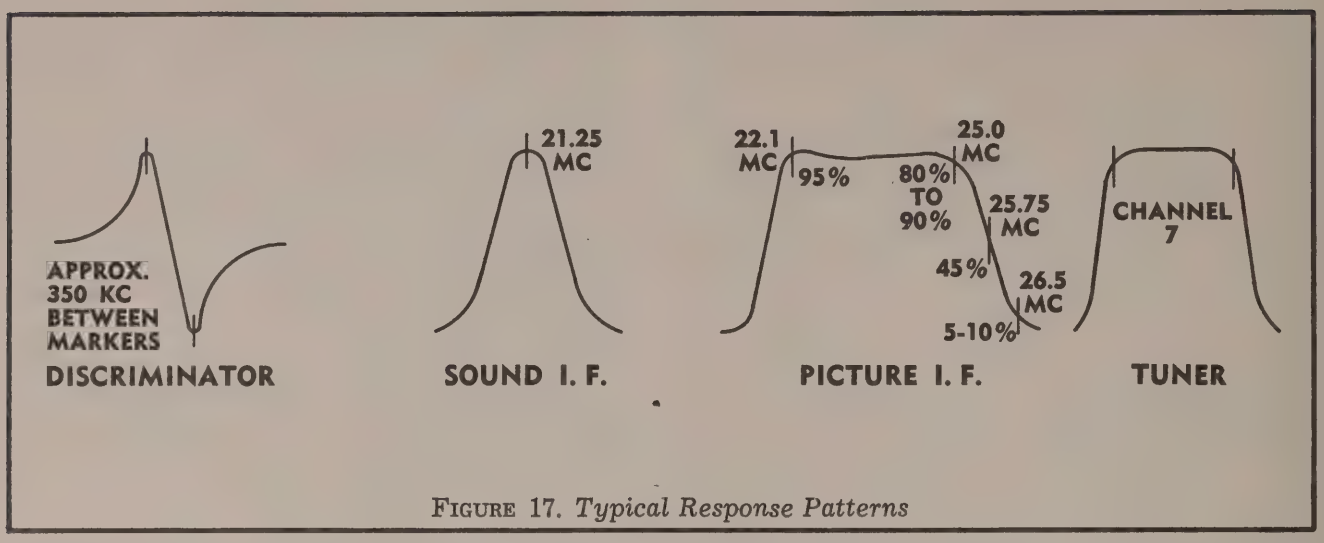


FIGURE 17. *Typical Response Patterns*

adjusting tool. In this position meter will read d.c. voltage across one of the diode load resistors.

3. Detune T113 secondary (bottom). This is a preliminary step to adjusting the primary and permits a true distinct meter reading as primary is peaked, tuning out influence of secondary. Now adjust the primary T113 (top) for maximum output.

4. Connect VTVM to junction of R236 and C205. At this point meter reads voltage across both diode loads. At resonance this voltage should be zero. Adjust T113 secondary for zero reading. Be certain to adjust for true zero resonance — true resonance is indicated when it is possible to tune secondary through zero and obtain a positive voltage on one side of resonance and a negative voltage on the other. Do this to clarify the point.

5. Connect sweep oscillator output to third i.f. grid through a series 1000 uuf capacitor. Set for approximately 1 mc. deviation with a 21.25 mc. center frequency and an output of approximately 0.1 volts (use r.f. VTVM).

6. Connect oscilloscope to junction of R236 and C205 through a 10K isolating resistor. Observe S-type response curve. Touch up primary and secondary for proper symmetry and bandwidth. Notice how the secondary influences the center-frequency (observe presence of 21.25 mc. marker) and symmetry of discriminator response while primary has greater influence on height or amplitude of output. Bandwidth should be linear from about 20.5 to 22 mcs. with a peak-to-peak bandwidth of 350 kc., figure 18.

C. Sound I.F. Amplifier

Tuned circuits of the sound i.f. amplifier are generally resonant to same frequency. Bandwidth, although important, is quite narrow. Consequently, sweep alignment is most often used because circuits can be peaked and, at same time, bandwidth observed and held symmetrical. A symmetrical bandwidth is necessary for distortionless audio.

1. Connect SWEEP OUTPUT to second sound i.f. grid. Attach VERT. input of scope in series with 33,000 ohm resistor to terminal A of transformer T112 (refer to schematic). Response curve is traced out by limiter grid current flow.

2. Any one of the sweep alignment interconnection methods can be used (refer to "Know Your Sweep Oscillator"). The phased 60 cycle sine method is perhaps the simplest. Turn up SWEEP WIDTH to approximately 1 megacycle deviation.

3. Set MARKER FREQUENCY to supply a 21.25 mcs. marker. Keep MARKER OUTPUT down to prevent distortion of pattern.

4. Adjust primary and secondary of transformer T112 for maximum gain and symmetry, figure 17.

5. Do final touch-up by setting FINE ATTENUATOR of sweep oscillator to deliver only a 0.3 volt peak at limiter grid circuit. Use voltage calibrator with scope to measure pattern. Bandwidth should be 350 kc.

6. Connect sweep oscillator to top end of trap winding of T2 (top of chassis). Adjust T11 (top and bottom) for maximum gain and symmetry (keep 0.3 volt peak at limiter grid by backing off sweep output).

d. Picture I.F. Traps

Precise tuning of resonant traps is very important to minimize interference and protect picture quality. When any alignment work is performed on the video i.f. amplifier it is important to have i.f. stages operating at proper level. To properly set level in the RCA chassis, contrast or picture control must be set to supply a specific amount of bias at the video i.f. grids.

Inasmuch as video i.f. bias has some influence on the resonant frequencies of the tuned circuits, it is advisable to align at bias levels normally present. For example, in most areas RCA recommends alignment with —3 volts on the video i.f. grids. For fringe area alignment it is advisable to align video i.f. with only —1 volt on the grids. Follow to the letter the bias recommendations of the manufacturer.

1. Set the channel switch to 13 to minimize influence of tuner on video i.f. alignment.

2. Connect d.c. VTVM across diode load resistor R137.

3. Connect the output of signal or marker generator to the junction of C14 and R6. Turn up generator output.

4. Set the generator to each of the following frequencies and adjust corresponding trap for minimum output.

21.25 mcs.	T2 (top)	T105 (top)
27.25 mcs.	T103 (top)	T102 (bottom)
19.75 mcs.	T104 (top)	

NOTE: WE CAN NOT OVEREMPHASIZE AGAIN THE IMPORTANCE OF PRECISE SETTING OF GENERATOR ON EACH OF THE ABOVE FREQUENCIES. REFER TO "CALIBRATION OF SIGNAL GENERATORS."

e. Video I.F. Alignment

In the alignment of the video i.f. section of the television receiver, single frequency, sweep alignment, or more often a combination of single frequency and sweep alignment are used. In stagger-tuned systems the individual resonant circuits are first tuned to their correct frequency using signal generator and VTVM. Overcoupled transformers and overall touch-up is then completed using a sweep generator. Follow manufacturers' recommendations in regard to biasing, and points and methods of connecting test equipment. Refer to section "Know Your Sweep Oscillator."

1. Set the picture control for correct i.f. bias — normally —3 volts and —1 volt for fringe area.

2. Connect the output of signal generator to the junction of C14 and R6. Connect d.c. VTVM across diode load resistor R137.

3. Set the signal generator to each of the frequencies indicated. Peak adjustment for maximum output. Reduce output of signal generator if necessary to obtain a sharp peak.

21.8 mcs.	T2 (bottom)
25.3	T103 (bottom)
22.3	T104 (bottom)
25.2	T102 (top)
23.4	L185 (top)

NOTE: WE CAN NOT OVEREMPHASIZE AGAIN THE IMPORTANCE OF PRECISE SETTING OF GENERATOR ON EACH OF THE ABOVE FREQUENCIES. REFER TO "CALIBRATION OF SIGNAL GENERATORS."

4. Connect sweep oscillator output to receiver antenna terminals. Connect oscilloscope across video detector load resistor (use 1000 uuf shunt capacitor and 10K series isolating resistor, figure 11).

5. Retain correct bias on i.f. grids.

6. Observe the response curve and adjust sweep oscillator output until a 0.3 volt peak-to-peak pattern is obtained.

7. Connect marker generator or calibrator to receiver antenna terminals. Adjust marker signal level so marker is just discernible on pattern and does not distort shape of response curve.

8. Analyze response curve and compare with figure 17. Check the various frequency points illustrated and make slight adjustments to obtain a near-perfect pattern. If response is defective in a certain section adjust those resonant circuits near in frequency to the defective point. Be certain to have picture carrier very near 45% level to obtain correct frequency response.

f. Tuner Alignment

Tuner alignment is not difficult if we can depend on our test equipment and we are careful to interconnect equipment properly. A number of important considerations are:

A. Sweep generator must have a linear output on each channel. Marker calibration must be accurate and generator must not load or distort shape of tuner response pattern.

B. At times it is convenient to do tuner alignment from a jig because of easier access to adjustments and non-handling of chassis. In such an arrangement be certain to apply correct bias and supply voltages as recommended by manufacturer.

C. Performance of some tuners is very much a function of chassis capacities and arrangement, and lead lengths to supply points. Do not align this type in a jig.

D. If tuner is aligned in chassis position be certain to supply correct a.g.c. bias and operating voltages.

E. Apply balanced or unbalanced signal to tuner input as required.

F. Apply enough signal to obtain a useable pattern on scope screen but not so much it would overload tuner. It should be possible to decrease output of sweep signal generator without changing shape of response pattern on screen (only the amplitude will become less).

G. Establish short good ground connections between sweep, tuner, and scope.

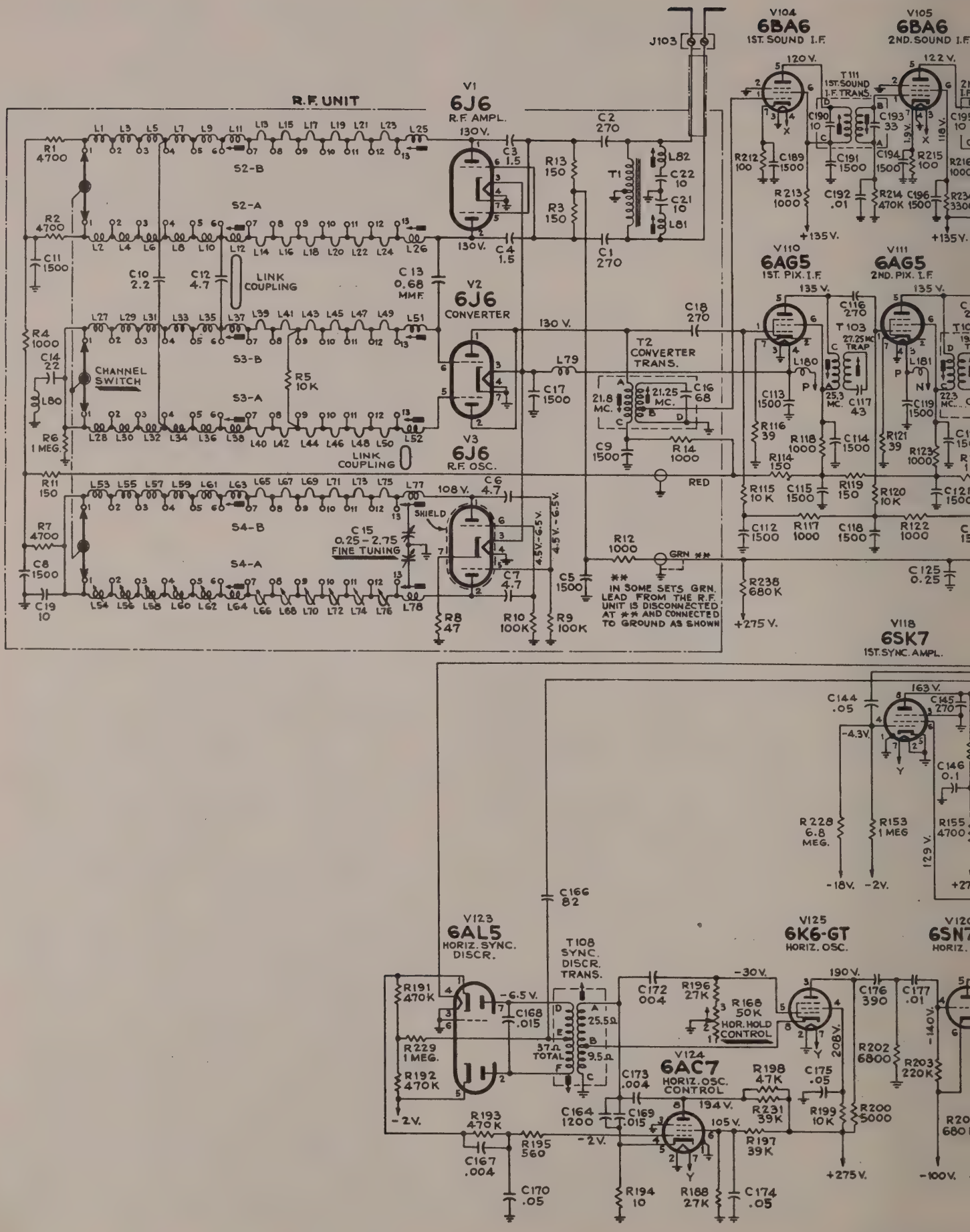
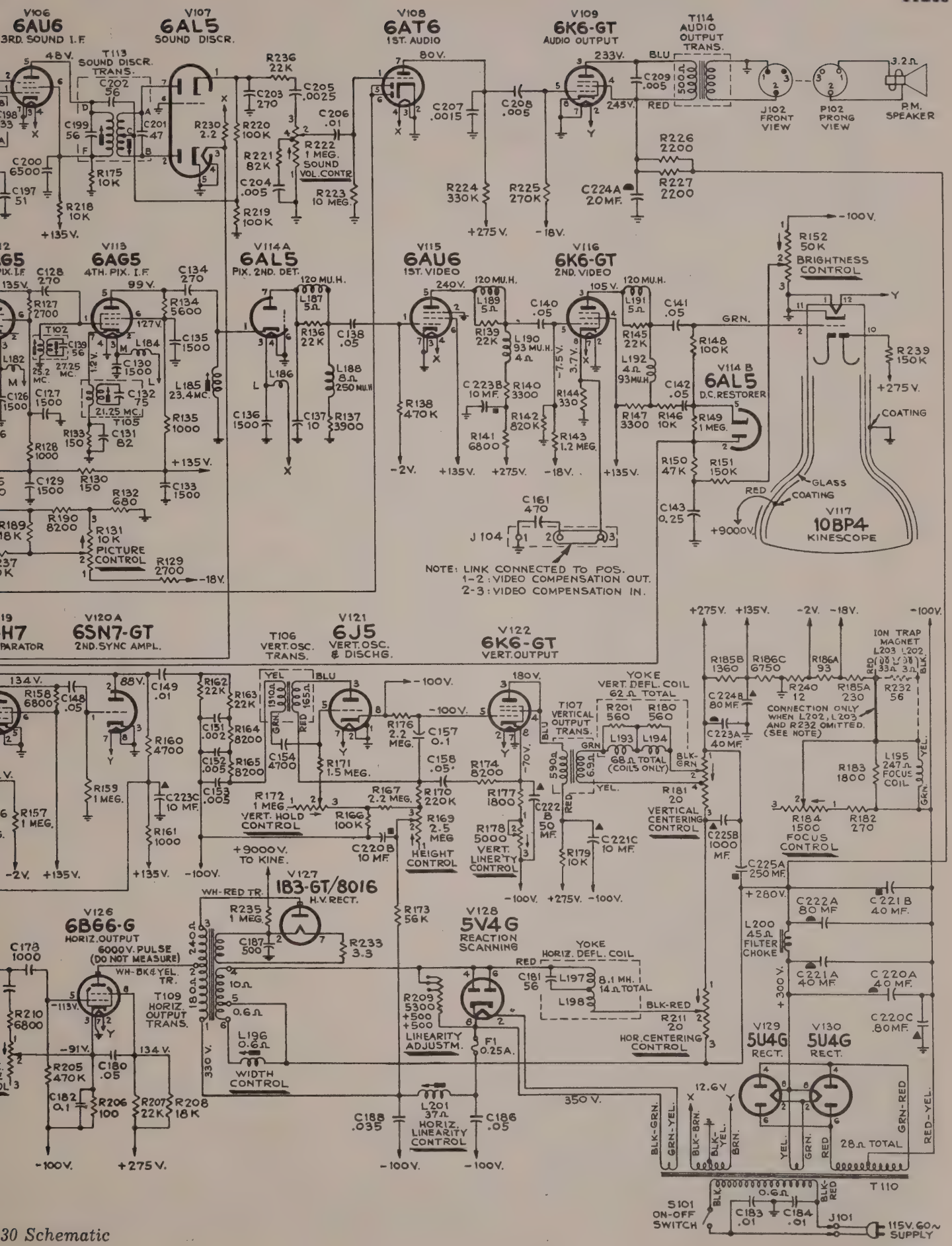

R.F. UNIT
V1
6J6
R.F. AMPL.
V2
6J6
CONVERTER
V3
6J6
R.F. OSC.
V104
6BA6
1ST. SOUND I.F.
V105
6BA6
2ND. SOUND I.F.
V110
6AG5
1ST. PIX. I.F.
V111
6AG5
2ND. PIX. I.F.
V118
6SK7
1ST. SYNC. AMPL.
V123
6AL5
HORIZ. SYNC. DISCR.
V124
6AC7
HORIZ. OSC. CONTROL
V125
6K6-GT
HORIZ. OSC.
T1
T2
CONVERTER TRANS.
T103
27.25 MC TRAP
T108
SYNC. DISCR. TRANS.
T111
1ST. SOUND I.F. TRANS.
CHANNEL SWITCH
LINK COUPLING
FINE TUNING
HOR. HOLD CONTROL
SHIELD
RED
GRN **
** IN SOME SETS GRN. LEAD FROM THE R.F. UNIT IS DISCONNECTED AT ** AND CONNECTED TO GROUND AS SHOWN
+135V.
+275V.
-100V.
-18V.
-2V.
-30V.
-6.5V.
-4.3V.
129 V.
208V.
-140V.

FIGURE 18. RC



30 Schematic

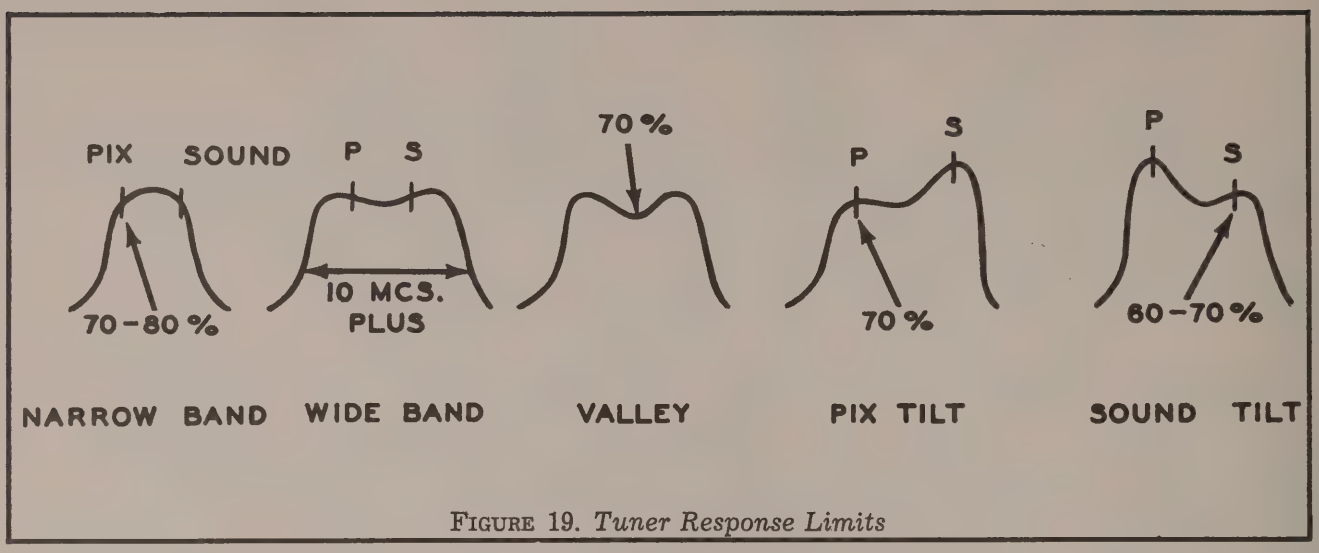


FIGURE 19. *Tuner Response Limits*

H. Know location and specific function of each adjustment. Follow recommended alignment procedure. Don't guess. Don't adjust indiscriminately.

Is Alignment Necessary. Complete and even partial alignment is seldom necessary except after tube replacement or circuit changes. If alignment curves are not true after a tube replacement, it is a good plan to substitute a few tubes to locate one with similar capacities as the one that had to be removed from service.

If upon checking a tuner, response curves are incorrect it is more likely there is a circuit defect rather than a need for alignment. So before becoming involved in an alignment procedure check tuner circuits critically. When defect is found and corrected, response curves are likely to return to normal.

Keep in mind that response curves on all channels are not likely to be ideal. Certain departures are permissible provided they do not go beyond certain limits, figure 19.

What Response Curves Tell Us. The nature of the distortion on a response curve can be a clue in deciding where a defect lies or what adjustment or tuned circuit has drifted away from correct alignment. In general the right and left sides of the overall response curve are influenced dominantly by the r.f. plate and mixer grid circuits. The bandwidth is set by the degree of coupling between these two resonant circuits. Often an adjustable control permits regulation of this coupling. The r.f. grid tuned circuit has its greatest influence on the overall height and the center section of the overall curve.

If one or more of the tuned circuits are seriously out of alignment the response curve will be weak and tilted as shown in drawing A of figure 20. Direction of tilt (picture or sound carrier the lower) is dependent on whether resonant circuit is mistuned above or below desired frequency. As tuned circuits are brought into correct relation pattern increases in amplitude as shown in curves B and C. Keep in mind when any of the three coils are far off, correct adjustment will have a great influence on pattern height.

Thus three adjustments — grid of r.f. stage, plate of r.f. stage, and grid of mixer are first adjusted until pattern has a maximum height. R.F. amplifier plate and grid of mixer are now adjusted until double hump appears, pattern D. Next step in alignment would be a critical adjustment of these three controls to obtain double-humped flat response. Fine adjustments of these three controls influence overall response as follows:

1. R.F. grid circuit has great influence on pattern height. It also affects center of response

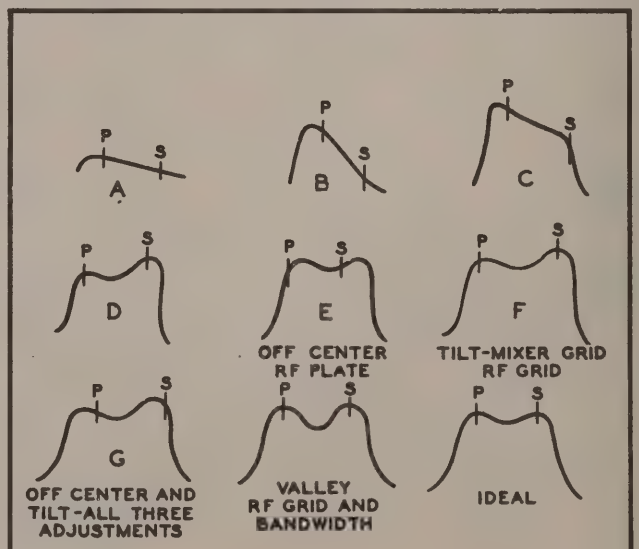


FIGURE 20. *Alignment Patterns*

curve and can introduce tilt if mistuned too far.

2. R.F. plate circuit can be used to shift pattern to right or left and helps to center response with respect to double-humps and two carriers. If mistuned too far it also can cause tilt.

3. Converter grid circuit has a dominant influence on tilt of overall response curve.

In summary, r.f. plate centers response with respect to double humps and two carriers — mixer grid and r.f. grid are set for minimum tilt and maximum height of curve. Any included bandwidth adjustments would be set to position carriers with proper spacing on double hump curve. Typical examples are represented in patterns E, F, and G.

When a valley or dip (I) or narrow single hump pattern appears, adjust r.f. grid and bandwidth adjustments. If tuner has no bandwidth adjustments, the r.f. plate and mixer grid must be retuned to remove valley or broaden bandwidth (sometimes at a sacrifice in height).

It is important to strive for maximum height at the same time we adjust for correct position and bandwidth. Often a decided change in height (sensitivity really) can be seen when a number of tubes is substituted as a search is made for the most sensitive tubes.

For complete information on tuners and tuner alignment refer to Notebook #4 "VHF-UHF TUNERS."

The RCA tuner has an untuned input and a double-tuned transformer between r.f. amplifier plate and mixer grid. Alignment is recommended in the sequence r.f. amplifier and mixer tuned circuits on the high band, r.f. amplifier and mixer tuned circuits on the low band, local oscillator on the high band, and local oscillator on the low band.

1. Connect sweep oscillator output to receiver antenna terminals. If sweep has an unbalanced 50 ohm output use a resistor network to match it to balanced receiver input, figure 21.

2. Connect oscilloscope to the junction of C14 and R6 through a series 10K resistor. Connect a 1000 uuf capacitor (short leads) from grid to ground of the first i.f. tube. This removes the influence of the i.f. input on the tuner response pattern. Set picture control for —1.5 volts bias on r.f. amplifier grids.

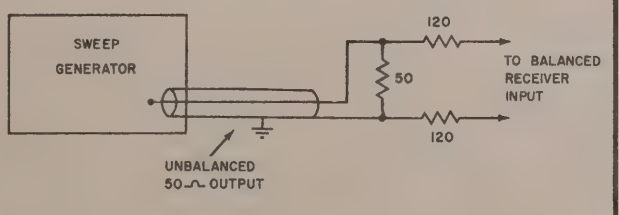


FIGURE 21. *Resistor Network for Balanced Input*

3. Set selector on channel 7. This channel has narrowest response on the high band and should be adjusted first. Adjust sweep oscillator and scope to observe channel 7 response curve.

4. Apply marker generator or calibrator to antenna input. Adjust marker level for discernibility of markers without pattern distortion.

5. Adjust L25, L26, L51, and L52 for approximate flat-top response, figure 18. These controls set the resonant frequency of the r.f. amplifier and mixer tuned lines.

6. Check the response of channels 8 through 13. Be certain response is satisfactory on each channel and carrier marker positions always above 70% level and within limits illustrated in figure 19. If patterns are not satisfactory, retouch and compromise the adjustments of step 5.

7. Set sweep generator, marker, and receiver on channel 6. Adjust controls L11, L12, L37, and L38 as per instructions of steps 5 and 6. Check patterns on channels 5 through 2 and retouch alignment adjustments if necessary.

8. Local oscillator can be aligned by applying sound carrier frequencies (stations or precisely set signal generator) to antenna input. Set fine tuning control to mid-point of its range.

9. Connect d.c. VTVM to junction of R236 and C205 of sound discriminator. Inasmuch as tuner is incremental coil type, local oscillator must be tuned on channel 13 first. Adjust L77 and L78 for zero reading between maximums.

10. Align each individual local oscillator adjustment in same manner in reverse numerical order (channels 12 down to 2).

FRINGE AREA ALIGNMENT

The tuner and i.f. amplifier along with the antenna system is an important cog in obtaining good fringe area pictures. We use the antenna system to intercept as much signal as possible. The tuner must make good use of whatever signal can be obtained. Again there are a number of important steps we can take to prepare a receiver for long range reception.

A. Be certain the best choice of tuner tubes has been made. Substitute a number of tubes in each circuit until best gain and least noise is obtained. By all means be certain local oscillator delivers optimum signal to grid of mixer (particularly on high band). With a 6J6 mixer, grid voltage as read on VTVM at grid should fall between —2 and —4 volts. A 6J6 oscillator should

have —2 volts at its grid at a very minimum. Readings for a 6C4 oscillator run a few volts higher. Pentode mixer grid voltages fall in a —4½ to —6 volt range.

B. The input circuit of tuner is of particular significance as it has a substantial influence on the height (sensitivity) of the pattern. It also has a great deal to do with the bandwidth and is generally loaded quite heavily for just that reason. Bandwidth of input circuit has its influence on signal-to-noise ratio — the wider its bandwidth the higher the noise and the more susceptible it is to interference. However, picture resolution is lost if bandwidth is made too narrow.

Nevertheless in fringe areas we are not able to make full use of resolution because of higher noise levels and background motion in the picture. Thus, we can sacrifice some bandwidth in favor of a more stable and higher signal-to-noise ratio picture. Most tuners shunt the input tuned circuit with a low value resistor to obtain bandwidth. The value of this resistor can be increased in steps until the peak pattern is obtained without too serious drop-off in resolution.

For example, with a typical tuner, response can be changed by removing or increasing value of loading resistor. This results in a substantial increase in gain, a narrower bandwidth, and a higher signal-to-noise ratio.

C. It should be stressed that in the preparation of a tuner for fringe area reception, pay strict attention to response on those channels to be received. A tuner is designed for optimum performance over a number of channels. Often desired channels can be favored in alignment at a sacrifice in performance on other channels — channels not used in that area. Align tuner first according to recommended procedures for all channel work. Check performance on desired channel or channels. Then go to work on desired channel to attain peak performance as per figure 22. This procedure often does so much good, changing parts is not necessary.

D. Response can be peaked on desired channels by working with main pattern controls. A bandwidth adjustment in particular can help in narrowing response, permitting circuit to pull up height without putting too deep a valley in overall response.

E. The video i.f. strip can also be peaked to increase receiver sensitivity and selectivity. First, align as per conventional procedure but at the low bias level (a.g.c.) likely to be found in fringe reception.

Next step is to raise level of picture carrier on response curve. Normally this rise would harm high frequency response but it goes unnoticed in normal fringe reception. Higher picture carrier level improves sync stability and permits best picture reception at same fine tuning setting as best sound. High frequency end response can be sacrificed to raise pattern levels at picture carrier frequency out to approximately 2 megacycles, figure 22.

The RCA chassis was peaked for fringe area operation as follows:

1. Connect i.f. sweep generator to antenna input terminals. Connect oscilloscope across video detector load resistor (use isolating resistor and shunt capacitor). Set picture control for —1 volt bias on i.f. grids. Obtain a 0.3 volt peak-to-peak pattern on scope (refer to previous section on "Alignment Methods").

2. Adjust T104 (bottom) so pattern level rises at picture carrier end of i.f. response and falls at low frequency end (high frequency video end). Continue adjustment until peak height of pattern begins to decline. Do same for L185 (top) also a low frequency end response adjustment.

3. Retouch T103 (bottom) and T102 (top) just slightly to place picture carrier at approximately 85% level.

4. If adjacent channel stations are to be received, align traps with great precision.

5. Tuner was also adjusted on the low band (reception of New York channels 2, 4, and 5 in Philadelphia area) by peaking tuner response as per figure. First normal pattern was obtained

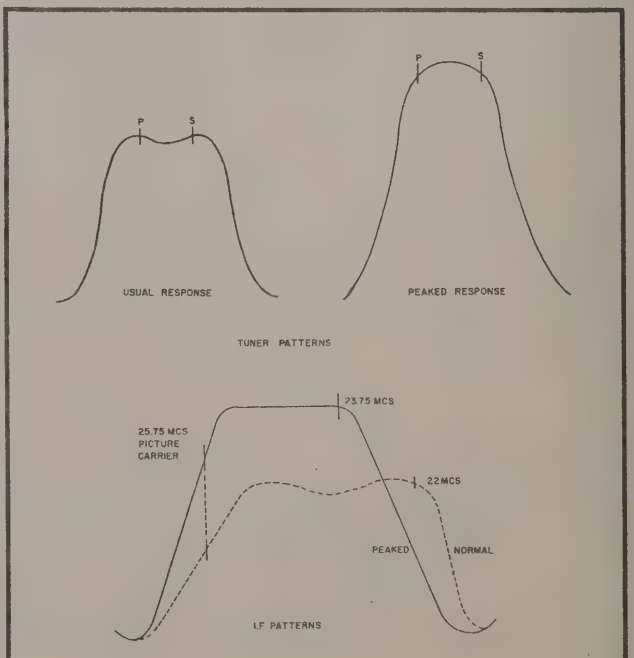


FIGURE 22. *Fringe Area Peaking*

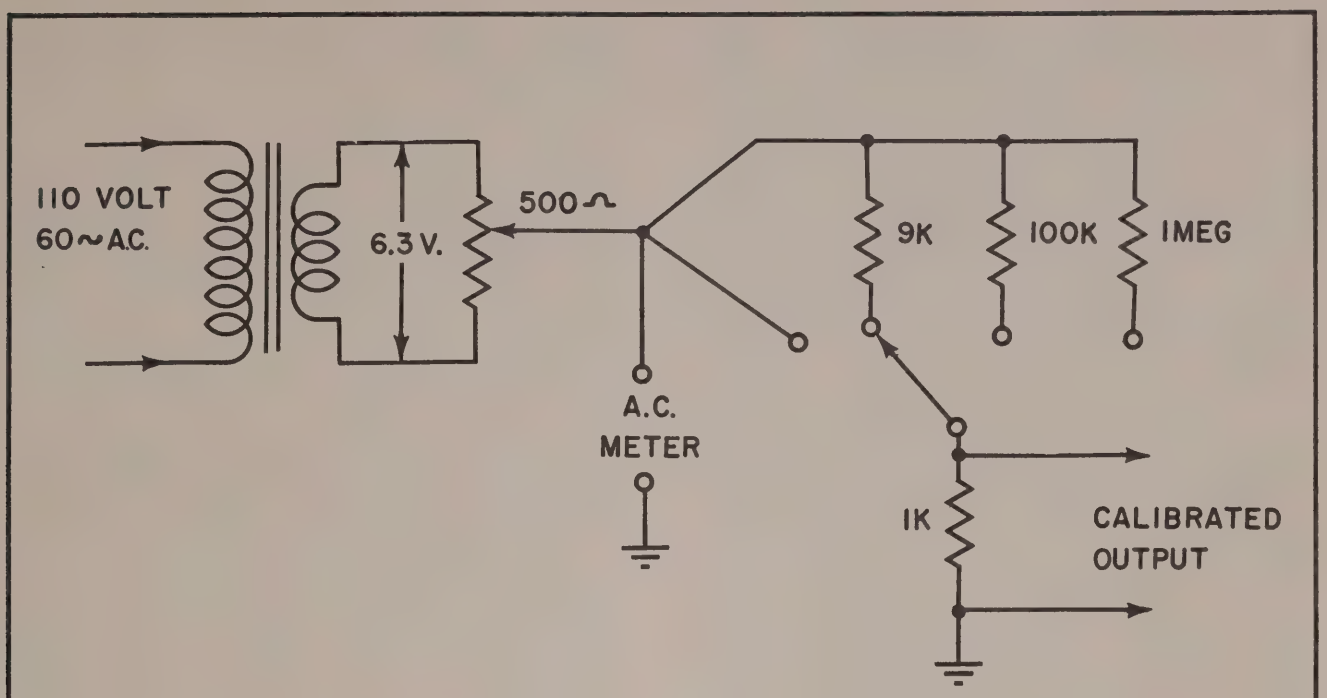


FIGURE 23. *Sensitivity Checker and Voltage Calibrator*

on channel 5 (refer to previous section on "Alignment Methods").

6. Remove bandwidth resistor R5 and reduce link coupling to nearer critical rather than overcoupled coupling.

7. Compromise adjustments L11, L12, L37, and L38 for maximum height and peaked tuner response as illustrated.

TEST EQUIPMENT CHECKS

To have the utmost confidence in your test equipment application and procedures you must be able to rely on your test equipment. However, these units are also vacuum tube circuits and subject to defects and wear.

Television Technicians Lecture Bureau has long recommended that each service shop purchase a few standard parts that can be used to keep close watch on test equipment performance. Typical units are as follows:

A. A few standard resistors and small 4½ volt battery can be used to check resistance readings in each range of VTVM or Volt-Ohm-Mil meters. Battery can be used to check and calibrate low voltage d.c. scales of voltmeters.

B. A standard voltage calibrator and sensitivity checker can be used to check deflection sensitivity of scope and accuracy of low voltage a.c. scales of VTVM and other a.c. voltmeters.

C. A few well-chosen crystals or signal calibrator can keep watch on frequency calibration of all signal and sweep generators. Refer to section on "How to Calibrate Signal Generators."

D. A well-calibrated r.f. VTVM or crystal detector can be used to keep check on output levels of signal generators. Output levels are measured at various frequencies with output turned up to maximum. Records are retained of all readings. At regular intervals the same readings are taken and compared with those on file.

SENSITIVITY CHECKER AND VOLTAGE CALIBRATOR

The technician must rely on his test equipment to give an indication of correct or incorrect operation of the device being serviced. His test instruments are electronic devices, too, and subject to defects after a period of operation. Methods should be employed in each shop to make routine checks of test equipment performance. It is important to keep test instruments working at peak efficiency if reliable and conclusive measurements are to be made.

A very simple unit can be constructed to keep watch on the sensitivity of the horizontal and vertical amplifiers of your scope. In addition to this application it can be used as a voltage calibrator, if your scope has no such facility, to measure voltage amplitudes of pulses and non-sinusoidal waveforms.

The test unit consists of a means of applying a weak 60-cycle sinewave signal at millivolt level to the vertical and horizontal input of the scope. With scope set for least attenuation and gain control set on maximum, the height of the pattern is measured. This reading is used to calculate

the number of millivolts of applied signal necessary to obtain an inch deflection on the screen. This reading is compared with manufacturer's figures of deflection sensitivity. If sensitivity is poorer than rated value, it is an indication of a weakness in the vertical amplifier. A decided weakness in gain often includes a non-linear or poor frequency response (also an important performance consideration) so nature of defect should be traced down. Same procedure can be used to check performance of horizontal amplifier.

At periodic intervals, scope sensitivity should be checked. Proper reading is a good indication of continuing amplifier performance. Consequently, there is no uncertainty as to scope performance when waveform observations and measurements are being made.

The very same device can be used to calibrate the vertical gain control and attenuator settings. After such a calibration is made it is possible to use scope quickly to measure the peak amplitudes of various waveworms applied to scope as a function of gain control setting and attenuator position. A means of checking waveform amplitudes in various circuits reliably affords an easier means of tracing down some of the more obscure receiver troubles.

The sensitivity checker can be used to calibrate your scope gain control dial so a chart can be prepared and you can evaluate waveform amplitudes almost instantly. You then have a means of direct comparison with waveform amplitudes recommended by receiver manufacturers.

A typical sensitivity checker, figure 23, consists of a 6.3 volt filament transformer, potentiometer. divider resistors, and an external a.c. meter (highly accurate). Voltage across output can be adjusted with potentiometer and measured by a.c. meter (divide reading by proper divider ratio 1, 10, 100, or 1000).

Procedure for checking scope sensitivity is as follows:

1. Connect output of sensitivity checker to vertical input of scope. Connect accurate a.c. meter to meter terminals of checker.
2. Set scope vertical gain on maximum and attenuator switch to position of least attenuation.
3. Adjust checker output potentiometer until one inch deflection is obtained.
4. Record a.c. meter reading and divide by divider ratio. Quotient is volts (r.m.s.) per inch deflection sensitivity.

Balanced Crystal Detector

Still another simple but useful device is the crystal detector, figure 24. This small unit, in conjunction with a sensitive microammeter of 0-60 microamps. or less, has a number of applications. It is fundamental being a low impedance r.f. termination and balanced crystal detector. Crystal current is measured by attaching a sensi-

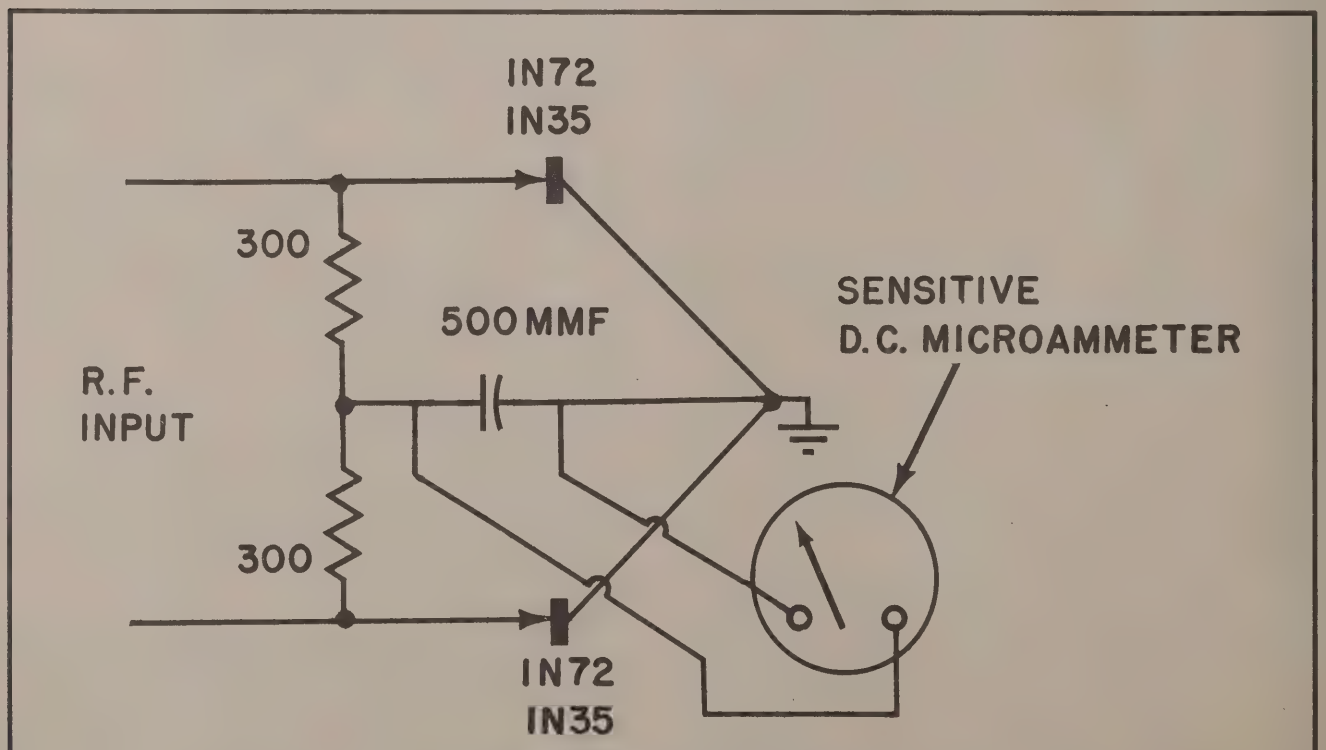


FIGURE 24. *Balanced Crystal Detector*

tive d.c. meter in series with crystal current output. High frequency is filtered by 500 uuf capacitor.

One **very important application** for the detector is to keep check on the output levels of the various signal generators in the shop. Here is a simple means of making routine scheduled checks and obtaining that added confidence that comes with knowing your test equipment is performing properly.

To check output of various signal generators proceed as follows:

1. Connect output of signal generator under check to input of detector. Connect sensitive current meter to output of detector (use most sensitive scale of your volt-ohm-mil meter or vtvm — 60 microamp. sensitivity or less than 60).

2. Set output of signal generator to maximum. Set on low frequency end of range. Observe and record output current reading. Observe and record output readings on other frequencies — low and high frequency ends of all ranges.

3. File these records and, at routine intervals, check generator with same detector. A change in readings at some or all check frequencies is an indication of performance deterioration. All shop generators should be checked in like manner.

Some additional applications for the balanced crystal detector are:

A. Alignment of boosters and peaking of specific channels.

B. Alignment of UHF converters.

C. Tuning of resonant circuits to specific frequencies.

Sweep Generator Linearity

It is necessary that the output of a sweep generator be absolutely linear if a true alignment curve is to be observed. Any non-linearity in the output of the sweep generator causes a distortion in the shape of the response curve. Thus, a true response pattern is not obtained and alignment procedures become indefinite, misleading, and inaccurate. Non-linear output defeats completely the utility of the sweep generator.

Linearity can be checked as follows:

1. Connect output of sweep generator to vertical input of scope. Turn output up to maximum and use almost full deviation.

2. Set oscilloscope controls for peak sensitivity (scope preferably should have a peak sensitivity of 20 millivolts per inch for critical observation).

3. If sweep generator output is linear a straight line will be obtained. If there is non-linearity on any range a distorted trace will be seen.

4. If your sweep generator is non-linear, the general shape of the distortion must be kept in mind when observing a response pattern — a difficult task.

5. Check linearity on video and sound i.f. ranges and on each television channel.

INSTRUMENT PROBES

Various types of probes increase the utility of test instruments. There are three basic types used with service test instruments.

A. The **high voltage probe** permits extension of the d.c. voltage range of volt-ohm-mil meter and VTVM. This permits measurement of high voltage power supplies.

B. The **high impedance compensating probe** minimizes loading of high frequency signal sources by the oscilloscope input impedance. It permits oscilloscope observation of pulses and other non-sinusoidal waves containing high frequency components without distorting their rise times or changing their shape.

C. **The r.f. or detector type probes** permit measurement of radio frequency signals. An r.f. probe (crystal or small vacuum tube diode) as used with a VTVM, rectifies the r.f. signal and applies the resultant d.c. component to the VTVM. With suitable calibration the meter deflection can be made a function of applied r.f. signal level. An r.f. probe as used with a scope detects the modulation on the r.f. signal (sine wave, video, or sweep pattern) and displays it on the scope screen. Deflection of course is a function of the r.f. signal strength.

Construction and Use of High Voltage Probe

The high voltage probe is basic, acting simply as a voltage divider. A high-voltage series resistor is built into the probe. Its value is based on voltage range to be covered and resistance of voltmeter with which it is to be used.

For example, assume a 12KV probe is to be constructed for a volt-ohm-mil meter of 20,000 ohms-per-volt and a 0-12 volt d.c.-scale, figure 25. Meter resistance on this scale is therefore 240,000 ohms. To permit a 12KV maximum measurement the probe resistor value would be:

$$R_{PROBE} = \frac{Et}{Em} \times Rm$$

$$R_{PROBE} = \frac{12{,}000}{12} \times 240{,}000 \doteq 240\ Meg.$$

Where:

Et equals peak voltage to be measured

Em equals full scale voltage reading on meter scale

Rm equals meter resistance on this scale

The high voltage scale on the meter is the 0-12 volt position and voltage measured is gotten by

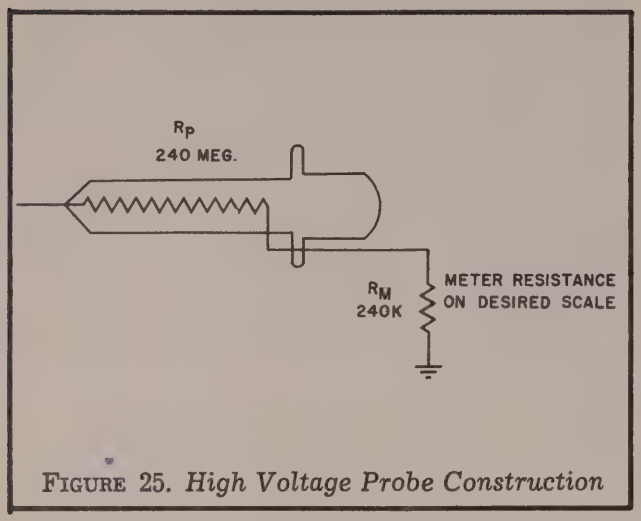


FIGURE 25. *High Voltage Probe Construction*

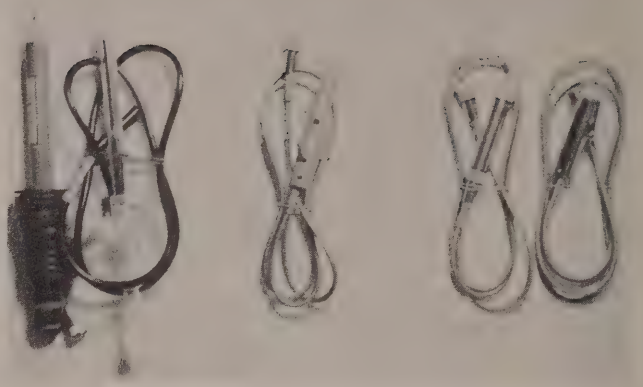


FIGURE 26. *Scope and VTVM Probes*

multiplying meter reading on this scale by a factor of 1000. Probe must be constructed of good high voltage insulation and provide maximum protection for the user, figure 26.

Use high voltage probe as follows:

1. Turn **OFF** high voltage source to be measured.

2. Connect high voltage probe to voltmeter. Set meter on correct scale.

3. Connect ground lead between receiver chassis and meter.

4. Turn on high voltage. Touch high voltage point with probe to obtain reading.

5. Multiply reading by correct factor. In example cited if meter reads 9 volts, the actual high voltage is 9000.

Construction and Use of High Impedance Compensating Probe

The high impedance compensating probe contains a parallel resistor and capacitor combination that is inserted in series with signal path to input of scope, figure 27. The combination along with the input impedance of scope (also an effective parallel RC combination) acts as a voltage divider and impedance transformer. Low frequencies divide across the resistances; high frequencies divide in same proportion across the capacitances. Thus, voltage division is uniform over a wide band of frequencies. However, addition of probe units (series units) raises the total impedance and presents a minimum load to any circuit to which scope is attached. Location of RC combination up in the probe also prevents cable capacity from loading circuit and shunting high frequency signal components.

Values of probe resistor and capacitor are determined by a balance between how much the impedance can be raised and how much a reduction in scope sensitivity can be tolerated. As input impedance is raised the sensitivity becomes poorer.

For example, if input impedance to a typical scope is one megohm shunted by an effective 50 uuf input capacity (includes capacity of cable) the input resistance can be increased to 10 megohms by adding a series 9 megohm resistor in probe. To retain same frequency response at highs and to isolate cable capacity, this resistor must be shunted by a 5.55 uuf capacitor (5 uuf close enough). Frequency response division is held constant by equalizing time constants — *RpCp* equal to *RinCin*.

Consequently, with probe added to scope the input loading is just 10 megohms shunted by 5 uuf capacity. However, the signal delivered to scope input is only at $^1/_{10}$th the level of signal applied to probe, reducing scope sensitivity by a factor of 10.

To increase input impedance by a factor of 20, a 19 megohm probe resistor and a 2.6 uuf capacitor are needed (same scope input impedance used in first example). Signal is attenuated by a factor of $^1/_{20}$ before application to scope input.

So far as probe application is concerned it can be used in same manner as conventional probe, keeping in mind the scope vertical gain will need to be set at a higher level. There will be much less loading of circuits to which scope is attached.

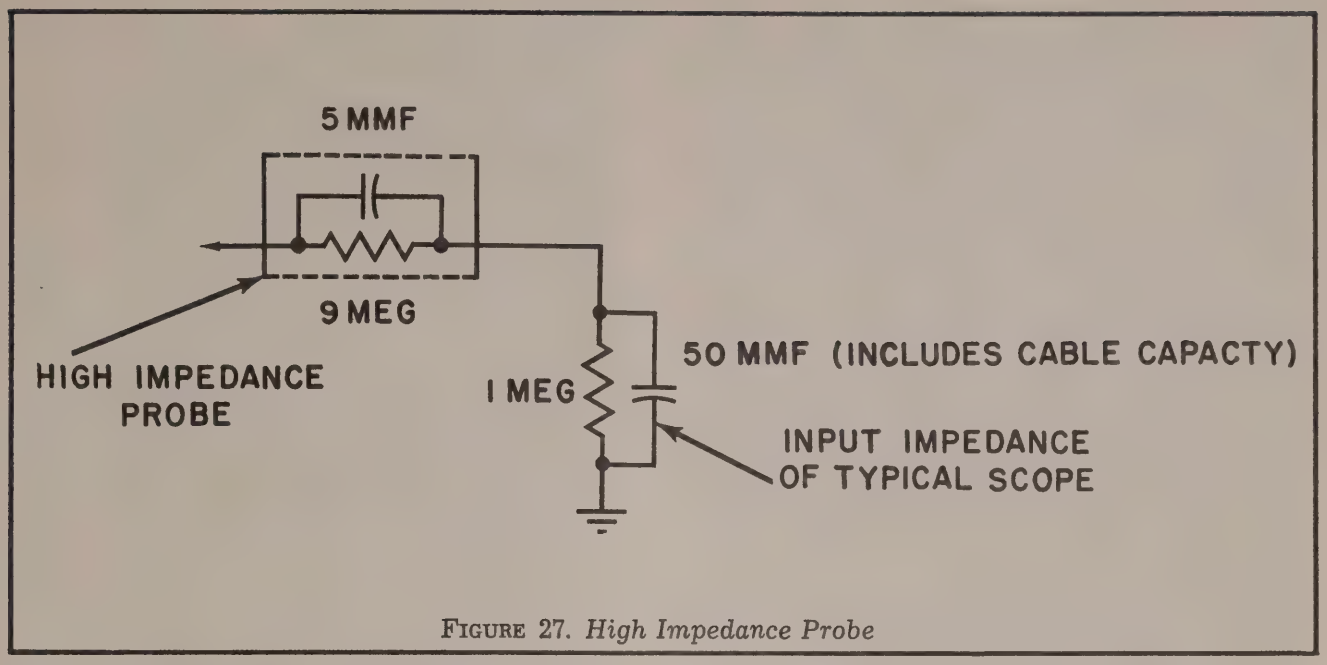


FIGURE 27. *High Impedance Probe*

Construction and Use of Radio Frequency Probes

The r.f. probe not only presents a means of measuring r.f. voltages but with proper design need only present a light load on circuit to which it is attached. A typical probe for a VTVM, figure 28, consists of a small rectifying diode, *RC* time constant, and filter. By limiting conduction time of diode to just a very small portion of r.f. cycle (long time constant and very minimum of shunt input capacity) a very high impedance is presented to source of signal. The very small Sylvania probe presents an effective 2.3 megohms shunted by 3.3 uuf. Such a probe can measure signals up to 300 megacycles with very light loading of r.f. circuits.

Probe can be used as follows:

1. Connect signal generator output to antenna input of television receiver.

2. Attach r.f. probe to VTVM and measure signal applied to antenna terminals.

3. Set signal generator output level to 0.1 volts on selected channel.

4. Use probe to check signal level at plate of r.f. amplifier. To obtain accurate readings when measuring r.f. voltages (particularly at frequencies higher than 30 mcs.) use extremely short ground lead. If at all possible touch ground terminal of probe directly to ground point of chassis.

5. Use probe to measure signal level at grid of first video i.f. stage. Continue to check signal level at each grid back through the i.f. strip. Notice how conveniently probe can be used to signal trace receiver and how easily it checks gain of individual i.f. stages.

A typical crystal type r.f. probe was shown schematically in figure 7. This type probe acts as a detector and removes modulation from r.f. signal and applies it to vertical amplifier input of an oscilloscope. To better understand its utility continue with procedures:

6. Apply modulation (generally 400 cycle) to signal being applied to antenna input from signal generator.

7. Attach scope probe to antenna terminals and adjust scope controls to permit observation of 400 cycle modulation.

8. Move scope probe back through stages of television receiver as per steps 4 and 5. Notice again how strength of detected signal increases, indicating performance and gain of individual stages.

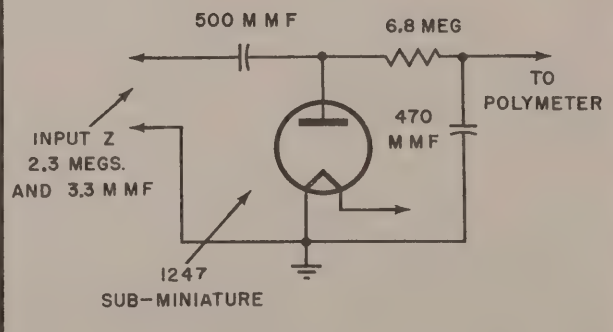


FIGURE 28. *Sylvania R.F. Probe*

9. Apply sweep signal to antenna input. Interconnect sweep generator and scope to obtain alignment pattern on screen.

10. Now move probe back through receiver stages again. Notice how response pattern can be picked up at each grid, indicating response up to each specific grid.

11. Disconnect signal generator and attach antenna to receiver. Tune in local TV station.

12. Move probe back through i.f. section again. Notice that actual video modulation appears on scope screen. Observe how video amplitude indicates stage performance and gain. This technique affords an easy, fast means of signal tracing requiring only scope, probe, and local signal.

Waveform Measurement and Observation

An oscilloscope is particularly helpful in the location of some of the more obscure troubles in the video, sync, and deflection systems of the television receiver. In most of these stages and in particular across high impedance circuits, a high impedance probe should be used with scope. The probe prevents loading, waveform distortion, and change of operating conditions in the stage being checked.

Waveform observation affords an excellent means of checking performance of pulse and non-sinusoidal circuits. Waveforms are compared with those recommended by manufacturer of specific receiver. A still more critical check is possible if a means of measuring waveform amplitude is available.

The three most common systems used to measure waveform amplitudes are:

A. Peak-reading vacuum tube voltmeter.

B. Oscilloscope with built-in calibrator and/or meter.

C. External home-constructed or commercial calibrator for scope.

The peak reading voltmeter has a scale calibrated in peak volts. Generally a reversing switch or lead reversing is necessary to obtain positive and negative peak excursions. Readings are added to obtain peak-to-peak value. There are often pulse frequency and/or duration restrictions associated with this type of meter.

The peak reading voltmeter that is built into scope affords a convenient means of measuring peak amplitude. With this arrangement the vertical attenuator and gain control are first adjusted so waveform occupies a suitable number of divisions on calibrated screen. Then a controlled 60-cycle sine wave is introduced and with a special calibration control is made to occupy same number of divisions. Peak voltage is then read off meter directly.

FIGURE 29. *Simpson Voltage Calibrator*

How to Use External Voltage Calibrator

The very same technique can be employed using an external calibrator, figure 29.

Simpson has developed a small meter that can be used for checking scope sensitivity, oscilloscope waveform amplitude measurements, and 60-cycle a.c. voltage measurements. The calibrator has RMS, Peak, and Peak-to-Peak scale calibrations. The RMS scales are 0 to 0.36, 0.9, 3.6, 9, 36, and 90. The Peak-to-Peak counterparts are 0 to 1, 2.5, 10, 25, 100, and 250. This means a 60-cycle sine wave voltage is available on all these ranges for application to oscilloscope for comparison with peak level of any waveform to be measured. Sine wave signal from calibrator can also be used to check the RMS deflection sensitivity of the scope. Refer to section "Sensitivity Checker." It is also possible to use meter to measure any 60-cycle external voltage source.

Proceed as follows to use an external voltage calibrator for waveform measurements:

1. Apply waveform to be measured to vertical input of scope. Adjust vertical attenuator and gain control so pattern occupies a suitable number of divisions on calibration chart in front of screen.

2. Remove waveform and apply calibrating

60-cycle sine wave. Do not touch scope vertical gain and attenuator settings. Adjust sine wave amplitude control until sine wave occupies same number of calibration chart divisions.

3. Read amplitude of applied sine wave. If only RMS calibration is available, reading must be multiplied by 2.82 to obtain peak voltage.

Such an external calibrator, figures 23 and 29, can be used to calibrate any vertical gain control and attenuator. With gain control calibrated (for a certain fixed amount of vertical deflection) a waveform can be made to occupy this prescribed amount of vertical deflection and peak voltage determined according to gain control setting. Calibrate gain control as follows:

4. Connect output of checker to vertical input of scope. Set vertical gain control on maximum and use attenuator position of least attenuation.

5. Apply sufficient signal from checker to obtain suitable deflection as a function of calibration chart divisions or size of screen (say, 3 inches on a five-inch screen).

6. Record voltage required to obtain this amount of deflection. Remember true peak voltage will be 2.82 times RMS reading.

7. Now decrease gain control setting a prescribed number of dial divisions (depending on how finely you desire to calibrate gain control).

8. Increase output of checker until same amount of vertical deflection is obtained. Record voltage.

9. Continue as above until gain control has reached minimum setting. A chart can now be tabulated or better still a graph drawn from the readings obtained. Now when any waveform is applied and is made to occupy the same number of divisions, the peak voltage can be gotten by referring to the chart of gain control setting vs. peak voltage.

10. Chart will apply to other attenuator settings by simply multiplying voltage read off chart times attenuator factor. If better accuracy is desired each attenuator position can be calibrated.

11. In measuring a signal so weak the prescribed deflection can not be obtained with gain control on maximum, measure height of pattern in inches. Multiply this value times the measured deflection sensitivity of the scope (refer to section "Sensitivity Checker and Voltage Calibrator). Since deflection sensitivity is given in RMS volts-per-inch, answer will also have to be multipled by 2.82.

Composite Signal Video Generator

A composite video generator, figure 30, generates a standard composite television signal that

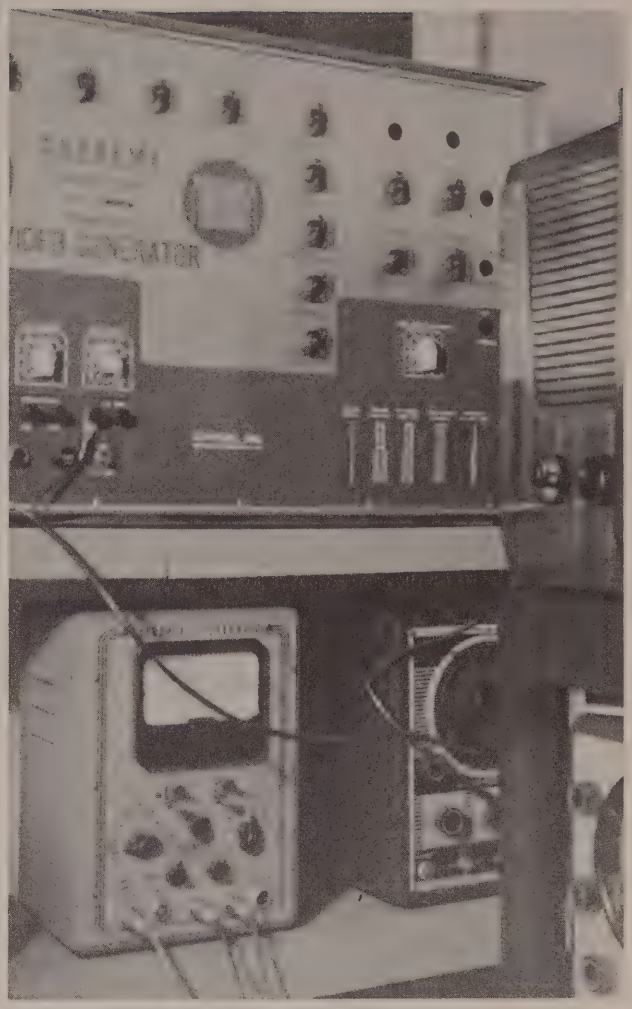


FIGURE 30. *Supreme Composite Video Generator*

can be used as an ideal substitute for a received television signal. Supreme video generator forms an FCC approved type of composite signal — sync, blanking, equalizing, and all. Video dot modulation is also available to supply an equivalent picture portion of a composite television signal. Generator has many applications in a service operation particularly when there must be mass repair of receivers. In large city service operations and/or in noisy locations the composite signal can be conveyed along a transmission line to various test bench positions. Thus, a source of video signal, clean and free of noise and interference is always available for repair work and checking of receivers. In weak signal and fringe areas, a composite signal is always available for repair and adjustment of receivers at a number of bench positions and technicians are not hampered by weak signals, noise, interaction, and other difficulties of weak signal distribution sys-

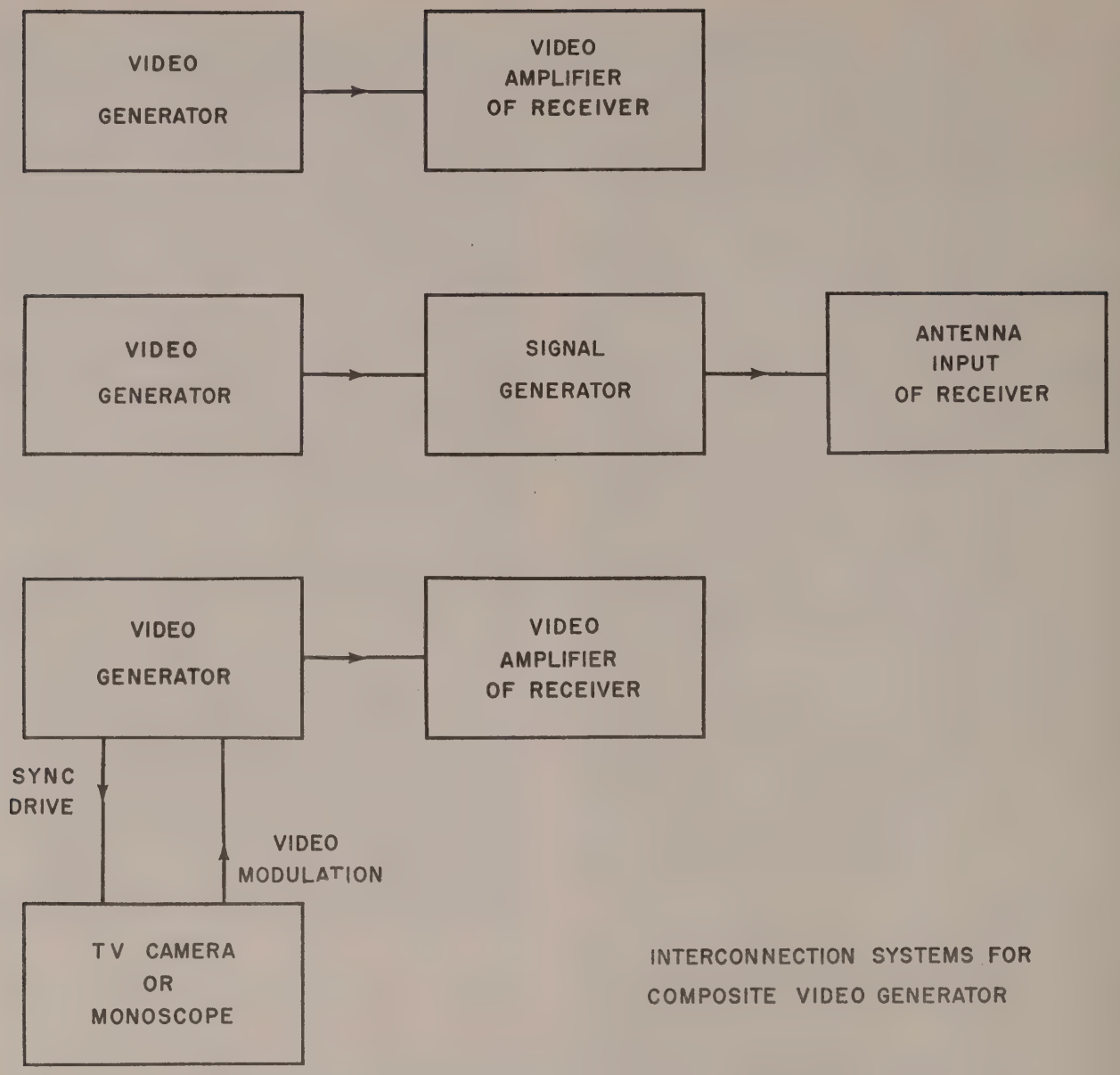


FIGURE 31. *Interconnection Systems for Composite Video Generator*

tems. There is no need for a station pattern as width, height, and linearity adjustments can be made with precision.

Composite video generator can be connected to receiver in a number of ways, figure 31. Video can be applied directly to input of receiver video amplifier or can be used to modulate a VHF signal generator and resultant modulated r.f. signal applied to antenna terminals of receiver. Video generator can also be used to supply sync drive excitation to a small television camera or monoscope. An actual picture signal is then formed instead of the video dot pattern.

There are numerous checks that can be made with composite video signal.

A. Video amplifier performance.
B. Sync separation system.
C. Inter-sync system.
D. Proper synchronization of vertical and horizontal sawtooth generators.
E. Performance of horizontal a.f.c. systems.
F. Performance of horizontal and vertical deflection systems.
G. Adjustment of picture width and height. This can be done with precision and reliability because oscillators are locked in at correct frequency.
H. Adjustment of horizontal and vertical linearity. These adjustments can also be made with reliability as dot pattern is precise — more so than many received station patterns.

Proceed as follows to use video generator:

1. Be certain video generator has been adjusted to form true composite signal. Follow instructions carefully. It should be possible to switch between a local station and video gen-

erator without having to readjust receiver hold controls.

2. Apply video signal from generator to video amplifier input of receiver. Set polarity and amplitude level for normal signal at that point. For example, in using the 8TS30 receiver as typical again, output of video generator was adjusted to deliver a 1.5 volt peak signal with sync negative to grid of first video amplifier V115, figure 17. Peak video level can be measured by attaching calibrated scope to this point. Refer to section "Waveform Measurement and Observation."

3. When raster is locked in (horizontal and vertical deflection on correct instead of free-running frequency) it is then possible to adjust picture width and height knowing it will be correct when a station is tuned in later.

4. Turn on dot generator circuit of video generator. Adjust vertical and horizontal linearity for uniform spacing of dots at all parts of the raster.

5. Attach scope to plate of first video amplifier and compare waveform with that recommended by manufacturer. Check waveform at various points in video amplifier. Notice how gain, response, and polarity can be observed.

6. Do same throughout the sync and deflection system of the television receiver comparing waveforms with those recommended in 8TS30 instruction manual or instruction manual of receiver you are using. Amplitude measurements as well as waveform observations can be made reliably using video generator and scope — an ideal means of signal tracing.

General Radio Diode Modulator

A crystal diode modulator developed by General Radio as a laboratory accessory has specific application possibilities in the service field. The modulator can be attached to the output of a signal generator and produce wideband amplitude modulation of that signal. Pulses, video signal, or a sine wave can be used as a source of modulating signal. An excitation level of just 0.2 volt rms can produce 30% modulation of a 50 millivolt r.f. carrier source. Video levels up to 4 volts peak can be accommodated for modulating higher r.f. levels.

Suitable sources of video for modulator would be a standard television receiver tuned to a local station or a composite video generator (refer to section "Composite Signal Video Generator"). Output could be taken off video output tube of receiver through a suitable divider network. This signal, modulator, and r.f. signal generator can be used to form a television signal on any television channel or band. Some applications for modulator are:

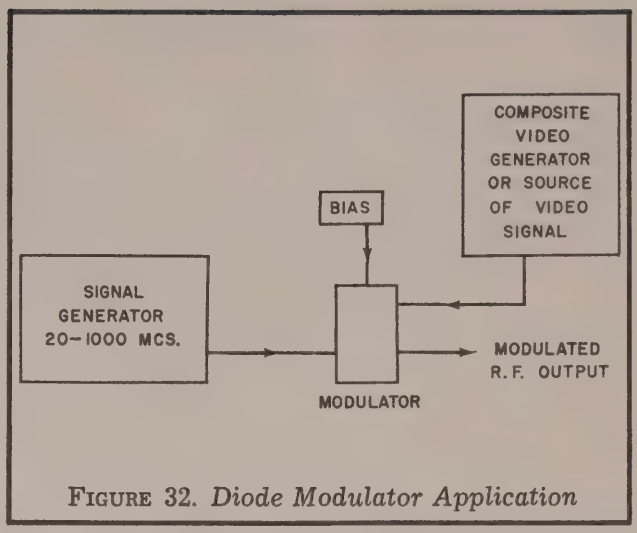


FIGURE 32. *Diode Modulator Application*

A. Can be used to modulate output of marker generator, signal generator, or sweep generator (deviation off) to form a video signal on any desired channel.

B. Can be used to modulate an i.f. frequency generator so video can be applied directly to i.f. strip.

C. Can be used to obtain a video modulated signal source on the UHF band to permit converter and tuner strip adjustments when UHF signal is not available or on the air.

D. In large service organizations, the modulator can permit formation of video modulated signal on any frequency to be piped along transmission line to various outlets. It can be used with composite video generator to modulate most any desired frequency, figure 32.

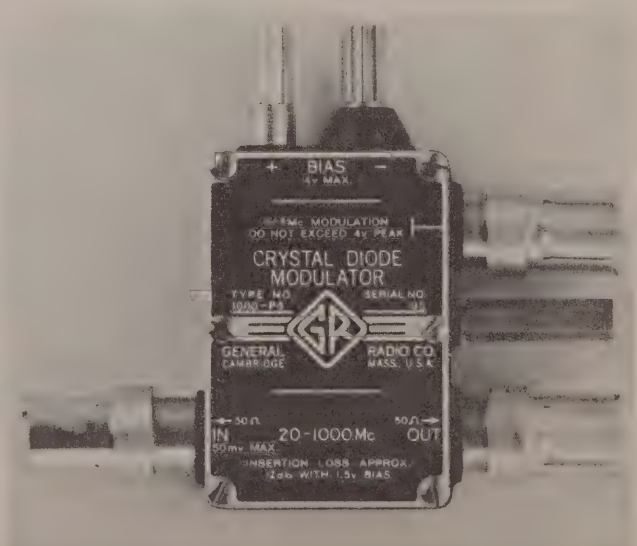


FIGURE 33. *General Radio Diode Modulator*

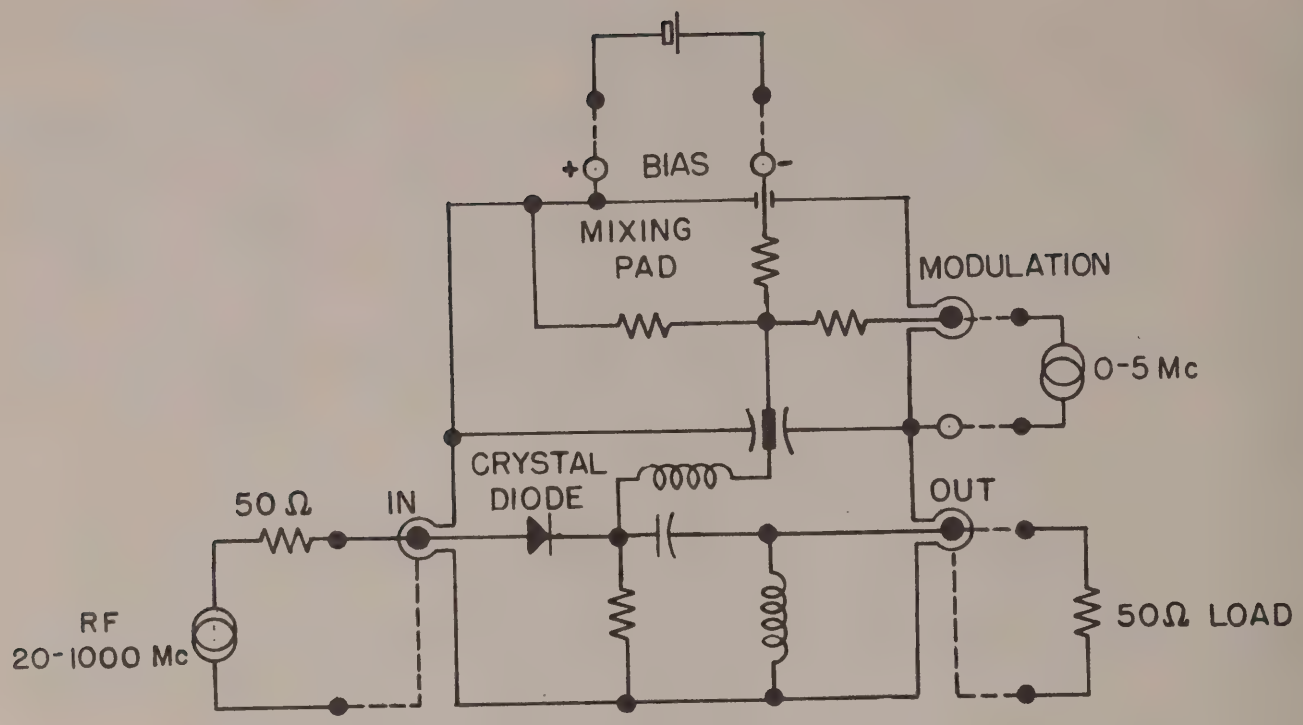


FIGURE 34. *RCA UHF Sweep Marker Generator*

The diode modulator, figure 33, consists of a crystal diode inserted in series with r.f. signal path from input to output. Through a mixing and isolation network the modulating voltage is applied across the crystal. The diode resistance changes with modulation, effectively creating amplitude modulation (power output variations) of the r.f. output. External bias is used to set optimum bias on crystal as a function of signal levels.

UHF TEST EQUIPMENT

Test equipment needed for the UHF band will be of the same fundamental types — reliable sweep-marker generators, scope, and meter.

Most all of the units mentioned throughout the manual have utility for UHF service. The UHF converters and plug-in adapters all have a number of resonant circuits that require adjustment. Single frequency alignment practice can be used for most. Insofar as a UHF converter i.f. system is concerned (50 to 200 mc. range), conventional VHF units can be used for alignment and signal tracing. VHF sweep oscillator and a scope with xtal probe can be used. For their UHF converter, GE recommends an accurate single frequency generator and balanced crystal detector of figure 24 in the alignment of the i.f. tuned circuits.

Single frequency practice can be used (station signal or accurate signal generator) in the alignment and tracking of many UHF tuned circuits. A small acorn or 6AF4 tube connected as an oscillator can serve as a signal source. To duplicate station reception the output of this small oscillator can be modulated using GR diode modulator as demonstrated in figure 32. Source of signal can be output of composite video generator or video from a local VHF station as removed from video amplifier of receiver.

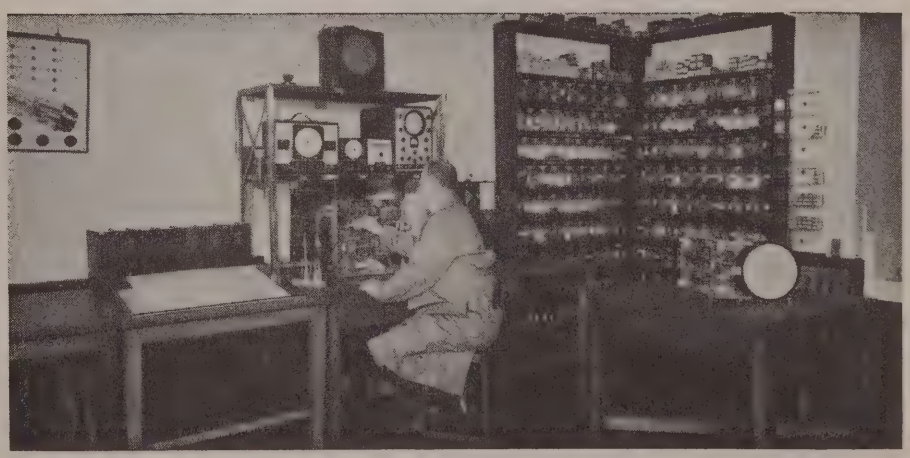
An accurate and versatile UHF sweep has been developed by RCA, figure 34. It spans the entire UHF range from 470 to 890 mcs. with a linear frequency deviation up to 45 megacycles. An accurate marker pip system provides markers for each megacycle over the entire UHF band. Instrument also includes a built-in detector and termination to make relative gain measurements over the entire band.

Some of the present VHF sweep and marker generators with high fundamental frequency bands do generate reasonably strong harmonics up in the UHF band. For example, the GE sweep generator, figure 12, has usable harmonics over the entire UHF band. It has a fundamental range of 165 to 220 mcs., and 3rd, 4th, and 5th harmonic ranges in the bands 495 to 660 mcs., 660 to 880 mcs., and 825 to 1100 mcs.

A Modern TV Service Shop

Designed for Profitable Servicing

By A. C. W. SAUNDERS
Director of the Saunders Radio and Electronic School



Shop Layout and Work Routine Spell the Difference Between Profit and Loss in a TV Service Business

The operating income of a service business is based on the profitable sale of "time" in the form of labor. All too often this fundamental business truth is forgotten or overlooked by men who operate as independents in the radio or television service business. When it is not taken into account the business sooner or later will become involved in financial difficulties.

The rugged individualists who fought for a living in the radio service business seldom gave much consideration to what their labor was worth. Operating usually as one-man businesses they managed to snatch a precarious living from their efforts through their versatility in being able to handle a wide variety of service jobs on radio and sound equipment. By adjusting their own

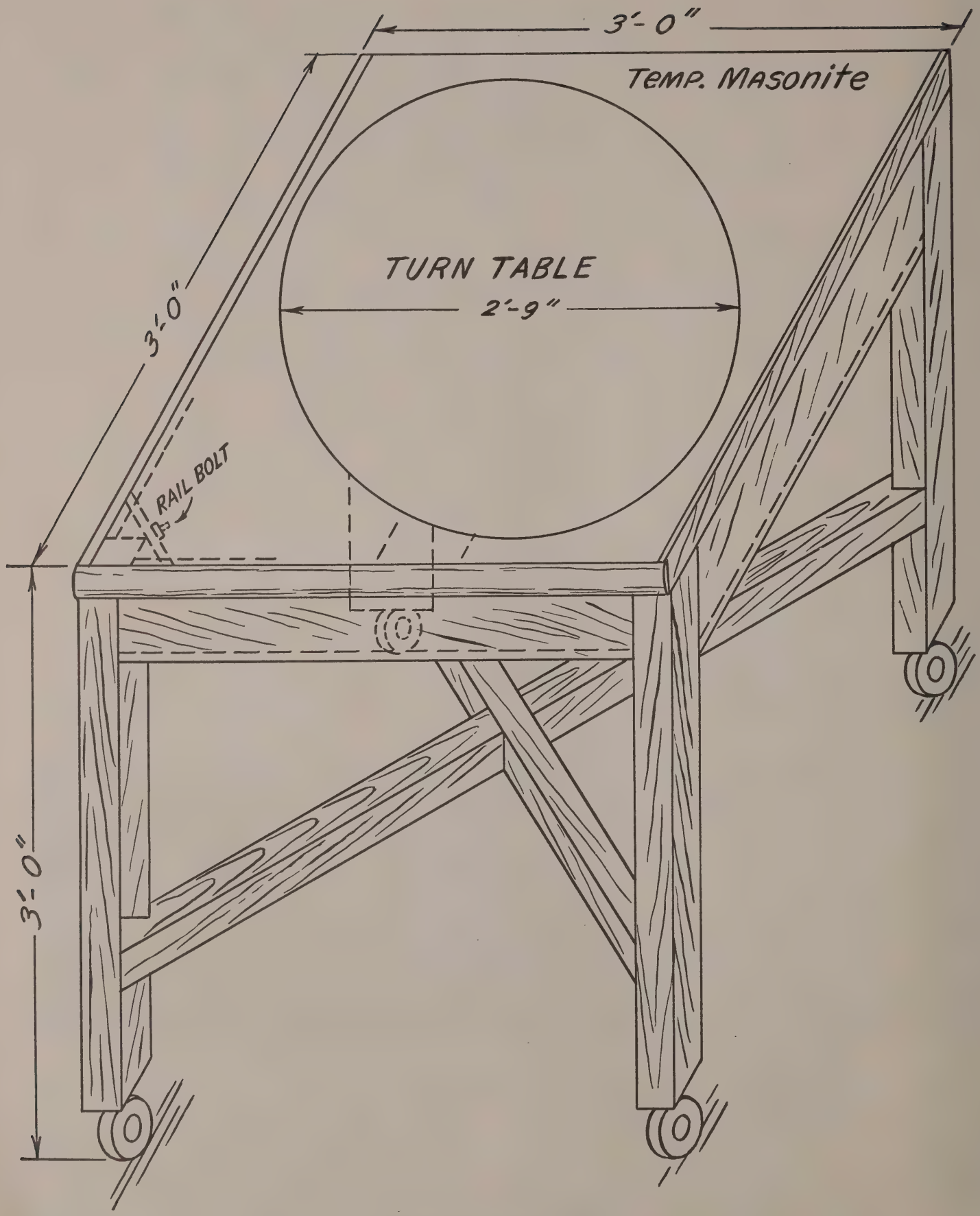


FIGURE 2. *TV Repair Dolly.*

standards of living in accordance with the varying income available from the business, they were able to continue as independent service technicians over a long period of time.

The average radio shop is an inefficient enterprise when considered as a business activity. Because of this many radio service shop owners had great difficulty or failed completely in adjusting their businesses to handle TV service. They have failed to recognize that television service is not just a bigger kind of radio service. Television service is a distinctly new kind of business and one which has many peculiar requirements of its own that must be met if the business is to be operated at a profit.

The heart of any service business is its shop. And it is in how efficiently the shop is laid out and operated that will greatly influence whether the business will produce a profit.

Competition will determine the prices that customers will have to pay for installations and for home service calls. Competition will also establish the wage levels for competent service analysts and technicians. The TV service business in which management planning provides for full utilization of its investment in servicing tools, equipment and the working hours of its employees will be the one that will continue to show an operating profit.

In our studies of the peculiar requirements for servicing television receivers we were greatly concerned by the almost insurmountable problems involved in trying to adapt a regular radio service bench for television servicing. A television receiver is a bulky unit and tricky to handle; the array of test instruments which should be instantly available to the technician working on a TV chassis requires a substantial amount of space and yet they have to be carefully and compactly set up to insure the accuracy of the instrument readings when applied to a service job. A proper installation of test instruments for TV servicing will eliminate all "guesswork" in the instrument readings.

Where TV chassis were brought into the shop and set on the floor we found numerous instances where technicians had developed hernias from handling the units from the floor to the bench and then back to the floor. Much time was lost in maneuvering chassis on the work bench to accomplish repairs, adjust controls and observe the response on the picture tubes.

In designing the "ideal" TV service shop our first objective was to minimize the amount of time required for the physical handling of the chassis in the shop. This was accomplished with a dolly mounted on heavy rubber-tired casters. These three-foot square by three-foot high units provide easy mobility of the jobs in the shop and they reduce the necessary handling of a chassis to two operations — the first is when the chassis is brought to the shop where it is placed directly on a dolly when it is taken from the field car or service truck; the second handling is from the dolly back to the truck after the chassis has been serviced and is ready for delivery to the customer. At no time does a shop technician need to lift the chassis.

To provide for easy maneuverability of a chassis during the analysis and servicing operations a 33-inch circular turntable was built into the top of the dolly. This permits free movement of the chassis during servicing and adjustment. It saves a considerable amount of time that is normally wasted in lost motions when it is necessary to lift and turn a chassis to accomplish the complete analysis, servicing and adjustment work.

The dolly is actually a sectional, mobile service bench. A complete dolly with its circular top is shown in figure 1 and construction details are shown in figure 2.

FIGURE 1. *The dolly as it appears with its circular turntable raised.*

The second vital requirement in a television service shop is for the test instruments to be readily accessible for any service job and so installed that the service technician can always depend on their readings as showing the conditions of the circuit under test.

To accomplish this objective a test instrument rack was designed to work in conjunction with the mobile dollies. The test instrument service position is a steel rack mounted on two 3′ x 3′ x 3′ tables which straddle a space that will accommodate a mobile dolly. In actual use the dolly containing a chassis is moved into position beneath the array of test instruments. The chassis can be quickly grounded to one of several convenient ground posts on the rack. The technician has instantly available for convenient use a Sweep Generator, Marker Generator, Oscilloscope and a VTVM with high voltage and signal tracing RF probes.

The necessary tools are easily accessible to his right and the complete service library is handily located to his left. The circuit diagram for the chassis undergoing repairs and adjustments may be placed under a sheet of plexiglas for rapid reference with a minimum handling requirement.

To permit picture tube observations while rear chassis adjustments are made, a piece of plate glass is mounted on the wall at the rear of the rack and in line with the mobile dolly position.

Details of a complete test equipment position are shown in figure #3.

TV service contractors who have adopted the plan of this modern TV service shop have followed the recommended practice of having enough dollies available to handle the normal flow of work going through their shops. The number of test instrument positions that are necessary in any given service shop will, of course, depend upon the volume of service business that must be handled and the number of technicians employed during peak seasons.

In addition to providing a clean, orderly and well-laid-out shop for their technical employees, service management also has the responsibility for directing work organization and analysis and servicing routines so that the technical man-hours they buy will be employed in productive work.

By all means, the proper use of test instruments in analyzing service jobs brought to the shop should be a "must." Hit-or-miss analysis of the complex circuitry of television receivers is too costly in lost time to be acceptable practice in a capably managed television service business.

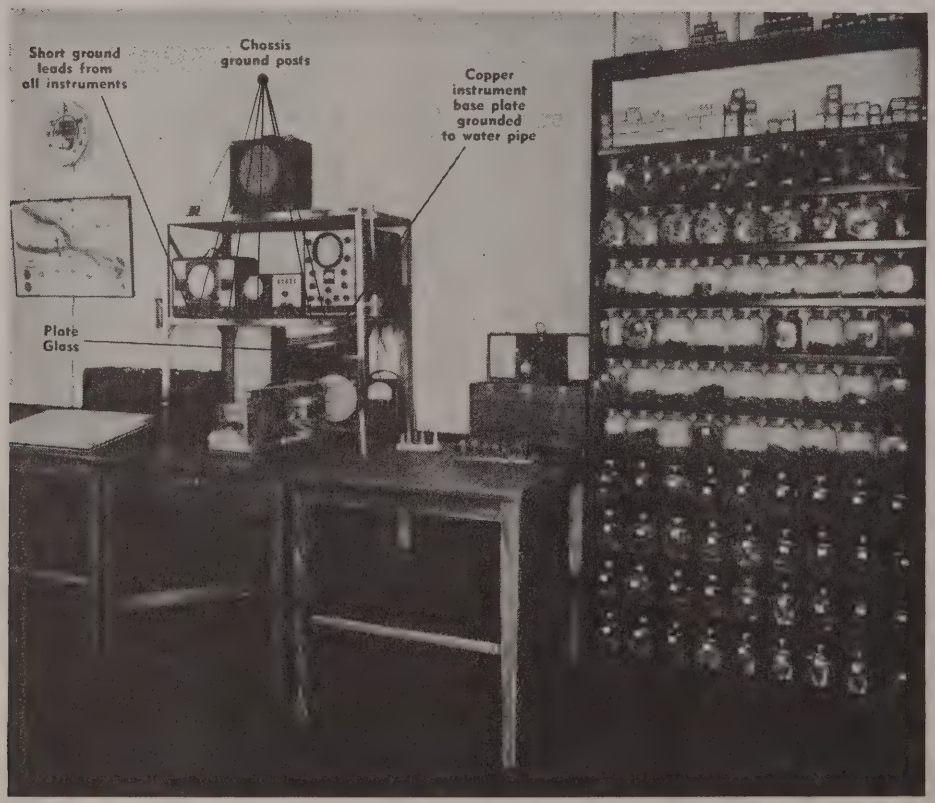
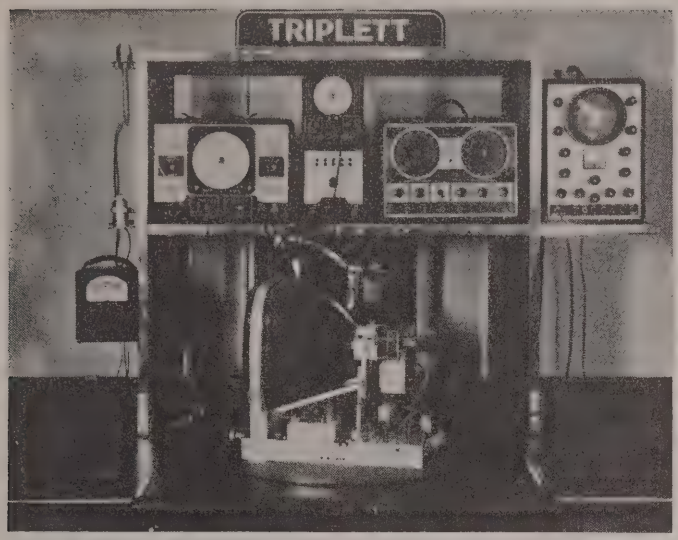
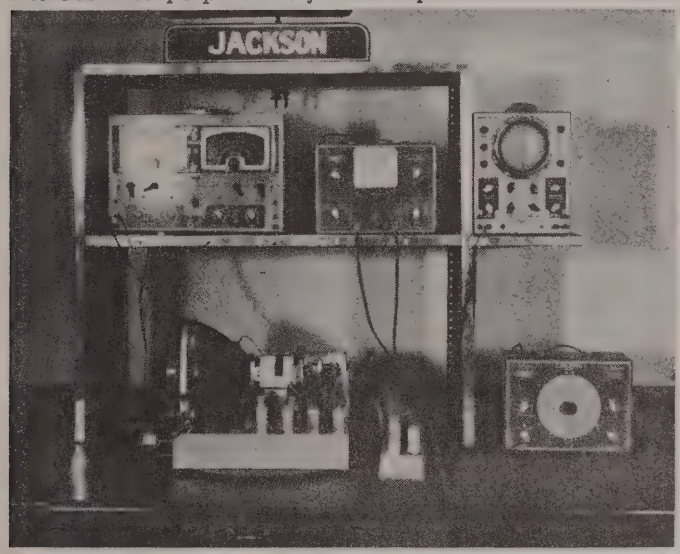

Short ground leads from all instruments
Chassis ground posts
Copper instrument base plate grounded to water pipe
Plate Glass

FIGURE 3. *Complete test bench with auxiliary facilities for efficient TV servicing.*

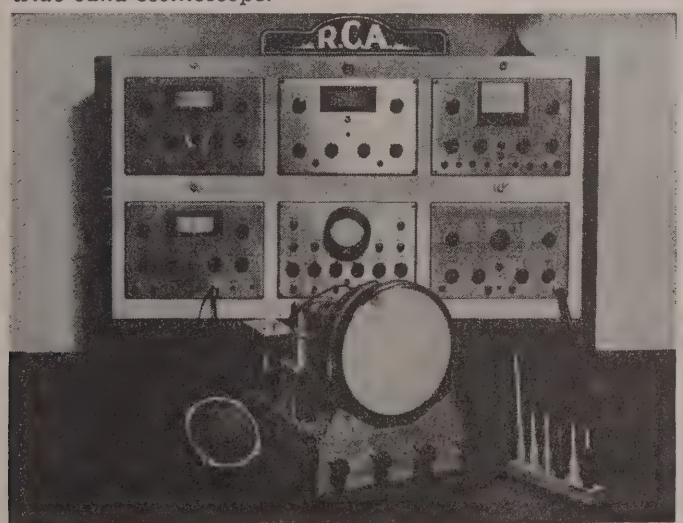
TEST EQUIPMENT RACK LAYOUT



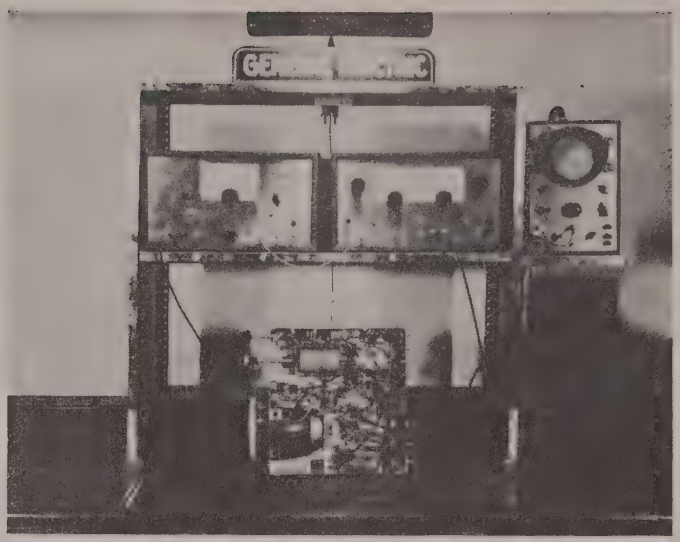
The Triplett Television Sweep Generator, the Variable Absorption type Marker, a Crystal Oscillator Marker with five crystal positions and additional combined Sweep Generator and Marker for sweep alignment. Associated Triplett Oscilloscope provides for a complete test rack.



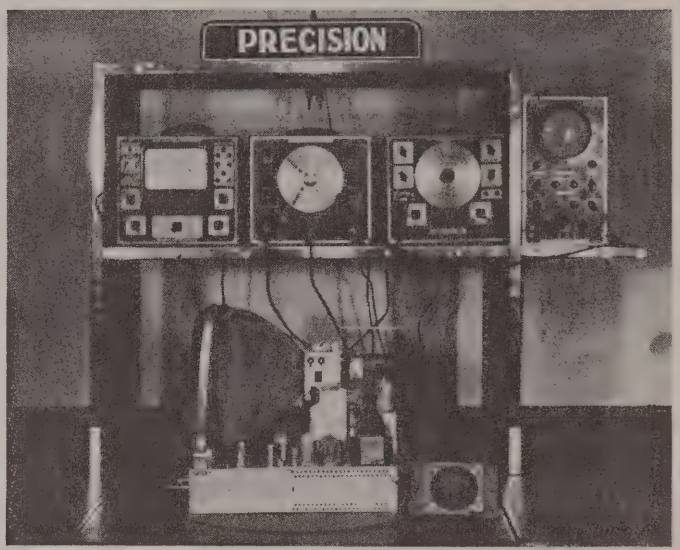
This position contains a Jackson TV sweep generator and marker generator, an RF signal generator and a sensitive wide band oscilloscope.



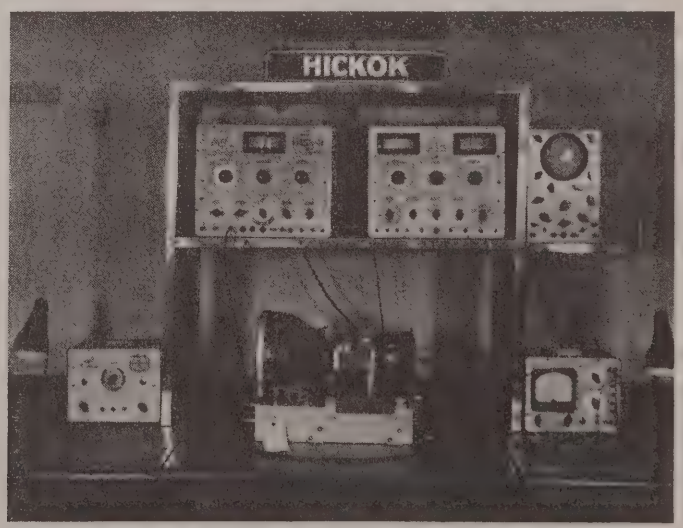
Six individual test units contained in a steel rack — from top-left to bottom-right these are a Variable Audio Oscillator, RF test oscillator, Vacuum Tube Voltmeter, Television Calibrator, Oscilloscope and Television Sweep Generator.



The General Electric Marker Generator, Sweep Generator and Cathode Ray Oscilloscope are matched for television alignment.



Shown from left to right are a Precision Vacuum Tube Voltmeter, Sweep Generator, designed for AM, FM and TV, Signal Generator and Cathode Ray Oscillograph.



The Hickok Television Alignment Signal Generator and Universal Signal Generator for TV visual alignment. Universal Generator also provides output for alignment and signal tracing of AM and FM receivers. A Hickok Linearity Pattern Generator produces a cross-hatch pattern for use in the absence of an actual broadcast television pattern.

Manufacturer	Model	Approx. Cost	Tube Size	Defl. Sensitivity (RMS)		Sweep Range	Input Impedance			Vert. Response	Misc. Features
				V	H		*Vert.	Vert. with Probe	Hor.		
Feiler	TS-7	$89.95	5	0.5	0.5	10~ to 35 kc	1 meg 50 mmf	1 meg 8 mmf	5 meg 50 mmf	20~ to 350 kc	Z Axis Headphone Jack
General Electric	ST-2A1	$298.50	5	0.015	0.35	10~ to 100 kc	1 meg 36 mmf	1 meg 10 mmf	1 meg 80 mmf	20~ to 1 mc	Retrace Blanking Z Axis Internal Calibrator
General Electric	ST-2A2		5	0.015	0.4	10~ to 100 kc	1 meg 36 mmf	1 meg 10 mmf	10 meg 35 mmf	20~ to 1 mc	Retrace Blanking Z Axis D. C. Amp (vert.) Internal Calibrator
Jackson	CRO-2	$197.50	5	0.018	0.55	20~ to 50 kc	1.5 meg 20 mmf		1.1 meg	20~ to 4.5 mc	60~ Sine Sweep Retrace Blanking Polarity Switch Z Axis
Hickok	505-A	$199.50	5	0.03	0.4	10~ to 25 kc	1 meg 25 mmf		4 meg 25 mmf	30~ to 1 mc	F M Modulator Retrace Blanking Sine Sweep
Hickok	195-B	$169.50	5	0.015	0.15	10~ to 50 kc	1 meg 25 mmf		4 meg 25 mmf	2~ to 1 mc	Sine Sweep Retrace Blanking
Precision	ES-500A	$169.50	5	0.02	0.5	10~ to 30 kc	2 meg 22 mmf		500 k 20 mmf	10~ to 1 mc	Z Axis Polarity Switch Retrace Blanking
RCA	WO-57B	$145.00	3	0.03	0.06	15~ to 30 kc	1 meg 35 mmf	1 meg 9.5 mmf	5 meg 133 mmf	0 to 1 mc	Calibrator Pre-Set TV Sweep Sweep Reversal
RCA	WO-56A	$217.50	7	0.01	0.02	3~ to 30 kc	1 meg 30 mmf	1 meg 9.5 mmf	1 meg 35 mmf	0 to 1 mc	60~ Sine Sweep Pre-Set TV Sweep Calibrator
Simpson	476	$179.50	5	0.02	0.04	15~ to 60 kc	300 k 30 mmf		500 k 15 mmf	20~ to 3 mcs	Z Axis
Supreme	650		3	0.5	0.5	20~ to 30 kc				20~ to 100 kc	
Supreme	655		5	0.3	0.3	20~ to 30 kc				20~ to 100 kc	
Supreme	660		5	0.1	0.14	7~ to 100 kc	5 meg 5 mmf	5 meg 9 mmf	5 meg 10 mmf	5~ to 5 mcs	Retrace Blanking Z Axis
Sylvania	132-Z	$149.50	7	0.1	0.25	15~ to 30 kc	500 k 26 mmf		500 k 33 mmf	7~ to 250 kc	
Sylvania	400	$249.50	7	0.1	0.5	15~ to 50 kc	5 meg 26 mmf		5 meg 31 mmf	10~ to 2 mcs	
Transvision	851	$295.00	5	0.1		20~ to 100 kc				10~ to 5 mcs	Z Axis 60~ Sine Sweep Peak Voltmeter
Triplett	3441	$185.00	5	0.01	0.15	10~ to 60 kc	2 meg 22 mmf		2 meg 35 mmf	10~ to 4 mcs	Calibrator Peak Voltmeter 60 Sine Sweep Retrace Blanking Polarity Switch Z Axis
Waterman	S-10-B	$76.00	3	1	1	10~ to 50 kc	500 k 36 mmf		500 k 36 mmf	20~ to 150 kc	
Waterman	S-14-B	$219.00	3	0.05	0.15	½~ to 50 kc	1 meg 25 mmf		1 meg 35 mmf	0 to 700 kc	Retrace Blanking

*Plus cable capacity.

VOLTAGE CALIBRATORS

Manufacturer	Model	Price	Ranges		Features
			RMS	P to P	
Hickok	630	87.50			
Simpson	276		0-0.36 0-0.9 0-3.6 0-9 0-36 0-90	0-1 0-2.5 0-10 0-25 0-100 0-250	Can be used to measure 60~ voltages in this range—includes meter
Sylvania	300	44.50		0-0.01 0-0.1 0-1 0-10 0-100	Supplies A 60~ square-topped wave for calibration

SWEEP GENERATORS

Manufacturer	Model	Approx. Cost	Frequency Ranges (Fund.)	Harmonic and Mixer Ranges	Deviation	Output Voltage	Marker Facilities	Special Features
General Electric	ST-4A	379.50	170-220 mcs 220-275	4-110 mcs	500 kc to 15 mc	0.5 0.1 1	Companion Unit	Retrace Blanking 20-70~ 300~ Adapter
Hickok	610 A	219.00	10 to 250 mcs Fund. & Harmonics		0-15 mcs		Included Marker Generator	Crystal osc.
Jackson	TVG-2	245.00	2-38 mcs 38-108 174-216		0-18 mcs	0.25	Included Marker Generator	Retrace Blanking 30~ Video input
Kay Electric MEGA Sweep				50 kc to 1000 mc	To 30 mc	0.1		
Philco	7008		4 to 120 mcs	144 to 260	0-15 mcs		Included Marker Generator	Included Scope
Precision	E-400	134.50	71-120 mcs	2-71 mcs 120-240 mcs 240-480 mcs	0-1 mc 0-15 mc		4 Position Crystal Calibrator	Narrow and Wide Band Sweep
RCA	WR-59B	274.50	Each TV Channel	300 kc to 50 mc	0-10 mc	0.1	Companion Unit	100-300~ Zero Reference
Simpson	480	395.00	142-260	2-120	0-15 mc		Included Marker	Crystal Calibrator Included Scope Model 479 without Scope
Supreme	675		FM and TV Ranges		0-10 mc		Included Marker	Video Input
Sylvania	500	139.50	132-360 mcs	2-25 mcs 20-60 mcs 60-120 mcs 140-230 mcs	0-600 kc 0-15 mc	0.1	Companion Unit	75~ Narrow and Wide Band Sweep
Triplett	3434	185.00	60-120	0-60 120-240	0-12 mc	0.3	Included Marker	50 and 300 ~ Model 3435 Available without Included Marker

SIGNAL AND MARKER GENERATORS

Manufacturer	Model	Price	Frequency Ranges	Output	Modulation	Features
General Electric	ST-5A	$395.00	20-27 mc 27-37 37-50 XTAL Control Harmonic on PIX Carrier of Each Channel			Markers for Sound Carrier Markers for Adjacent Sound
Hickok	292-X	$266.00	125 kc to 120 mcs 150 to 220 mc	0.1		XTAL OSC from 152-162 mc
Hickok	288X	$186.00	100 kc to 110 mc		400~	AM-FM Modulation
Jackson	106	$58.31	100 kc to 54 mc 54 to 216 mc		400~	
Jackson	TVG-2	$245.00	4-16 mc 16-29 27-54 54-216	0.25	400~	Separate XTAL Oscillator Phone Jack for Beating Part of Sweep Generator
Kay Electric MEGA-Marker			4.5 mcs 19-29 mcs 29-39 mcs			
Kay Electric MEGA-PIX			Picture and Sound Carriers on all Channels	0.03	2,000	
Oak Ridge	103	$33.50	54-216 mc 4.5 mc 20-28 mc 40-48 mc		500~	Modulated and Ummodulated Output Available
Precision	E-200-C	$71.25	88 kc to 30 mc Fund. 30-120 mcs		400~	
RCA	WR-39C	$242.50	250 kc to 480 mc			Linearity Bar Patterns Available Dual Markers Crystal Calibration Heterodyne Freq. Meter AM-FM Generator with FM Sweep
Simpson	479 480	$269.00 $395.00	3.2-15.6 15-76 75-250		400~	Crystal Calibrator part of Sweep Generator
Supreme	675		19-50 mc			Crystal Jack part of Sweep Generator
Supreme	666		65 kc to 20.5 mcs Fund. 20.5-120		15~ to 15 kc	R. F. Carrier Meter Scope Sweep for Visual AM Alignment
Sylvania	216	$139.50	80 kc to 120 mcs Fund. 120-240 mcs	1.0	400~	AM Modulation Narrow Band FM Modulation R. F. Meter 1 mc XTAL Calibration
Sylvania	501		15-240 mcs Crystal osc 2-20 mcs			Crystal Calibrator
Triplett	3434	$185.00	19.5 to 40 mcs Fund. 40-240	0.3	400	Part of Sweep Generator Separate Crystal Oscillator
Triplett	3432		165 kc to 40 mcs Fund.		400	

VACUUM TUBE VOLTMETERS

Manufacturer	Model	Price	Ranges				Impedance	Misc. Features
			D. C.	A. C.	R. F.	Ohms		
Feiler	TS-9	$48.95	0-5/10/100/500/1000	0-5/10/100/500/1000		0.2⌁ to 1000 meg	26 meg DC 3 meg AC	Zero Center Scale Polarity Switch 0-1 MA Scale
Feiler	EV-20		0-3/12/30/120 0-300/1200 H. V. Probe to 30,000	0-3/12/30/120 0-300/1200	R. F. Probe 0-3/12/30/120 to 300 MC	0.2⌁ to 2000 meg	13.3 meg DC 1000⌁/V AC	Zero Center Scale Current Scales
Feiler	EV-10A		0-3/12/60/120 0-300/600/1200/6000	0-3/12/60/120/300 0-600/1200/6000	R. F. Probe 0-3/12/60/120 to 300 MC	0.2⌁ to 2000 meg	13.3 meg DC 1000⌁/V AC	Zero Center Scale Current Scales
Jackson	109	$58.31	0-4/10/40/100 0-400/1000	0-1/4/10/40/100 0-400/1000	R. F. Probe to 4.5 MC		12 meg DC 4.4 meg AC	
Precision	EV-10A MCP	$94.50	0-3/12/30/120/300 0-600/1200/6000	0-3/12/30/120/300 0-600/1200/6000	0-3/12/30/120	0-2000 meg	13.3 meg DC 1000⌁/V AC	Zero Center Current Ranges
Precision	EV-20	$68.25	0-3/12/30/120 0-300/1200. To 30 kv with probe	0-3/12/30/120 0-300/1200	0-3/12/30/120	0-2000 meg	13.3 meg DC 1000⌁/V AC	Zero Center Current Ranges
RCA	WV-97A	$67.50	0-1.5/5/15/50 0-150/500/1500	0-1.5/5/15/50 0-150/500/1500	0-1.5/5/15/50 0-150/500 to 3 MC Special Probe to 250 mc	0-1000 meg	11 meg DC 0.83 meg AC 70 mmf	Peak Reading Center Scale
Simpson	303	$66.70	0-1.2/12/60/300 0-1200 To 30 kv with Probe	0-1.2/12/60/300 0-1200	0-20 20 kc to 100 mc	0-1000 meg	10 meg DC 275 k AC 200 mmf	Zero Center
Simpson	266	$125.40	0-1/5/10/50/100 0-250/500/1000/5000 To 25 kv with probe	0-1/5/10/50/100 0-250/500/1000/5000	R. F. Probe available	0-1000 meg	50-200 meg DC 6 meg AC	Current Scales
Supreme	574		0-1/2.5/50/250 0-500/2500	0-1/2.5/50/250 0-500/2500	0-2.5/250. With probe to 100 mc	0-1000 meg	20 meg DC 20 k and 9 mmf at 100 mc	Current Scales
Sylvania	221Z	$99.50	0-3/10/30/100 0-300/1000 Probe to 30 kv	0-3/10/30/100 0-300/1000	0-3/10/30 0-100/300 To 300 mc	0-1000 meg	16 meg DC 2.7 meg AC 125 mmf 2.3 meg RF 3 mmf	Current Scales Zero Center
Triplett	650		0-1/5/10/100 0-500/1000 Probe to 50 kv	0-1/5/10/100/500	0-1/5/10/100/500 Probe to 980 MC	0-1000 meg	11 meg DC 1 meg and 13 mmf at 1 mc	Peak Reading Scales Zero Center
Weston	769		0-3/12/30/120 0-300/1200	0-3/12/30/120 0-300/1200 1000⌁/V	0-3/12/30/120 Probe to 300 mc	0-2000 meg	15 meg DC 5 meg RF 5 mmf	

VOLT—OHM—MIL METERS

Manufacturer	Model	Price	Ranges			Ohms	Misc. Features and Ranges
			D. C. Volts	A. C.	Current		
Hickok	450	$46.50	0-2.5/10/50 0-250/1000/5000 20,000~/V	0-2.5/10/50 0-250/1000/5000 5000~/V	0-2.5/10/50 0-250/1000 0-50 μamp 0-10 amps	0-1000/10 k 0-1/100 meg	DB Scale
Oak Ridge	105	$38.95	0-2.5/10/50/250 0-1000/5000	0-2.5/10/50/250 0-1000/5000	0-10/100/500 0-100 μamps	0-200/200 k 0-20 meg	DB Scale
Precision	40	$26.25	0-3/12/60/300 0-1200/6000 1000~/V	0-3/12/60/300 0-1200/6000 1000~/V	0-.6/6/60/600	0-5000/.5 meg 0-5 meg	DB Scale
Precision	80	$34.50	0-6/12/60/300 0-1200/6000 1000~/V	0-6/12/60/300 0-1200/6000 1000~/V	0-.6/6/60/300 0-1.2/12	0-1 k/100 k 0-1/10 meg	DB Scale
Precision	85	$39.95	0-3/12/60/300 0-1200/6000 20,000~/V	0-3/12/60/300 0-1200/6000 1000~/V	0-1.2/12/120 0-1.2-12 amp 0-120 μamp	0-6 k/600 k 0-6/60 meg	DB Scale
Simpson	240	$26.35	0-15/75/300 0-750/3000 1000~/V	0-15/150/750 0-3000 1000~/V	0-15/150/750	0-3k/300 k	
Simpson	260	$38.95	0-2.5/10/50/250 0-1000/5000 Probe to 25 kv 20,000~/V	0-2.5/10/50/250 0-1000/5000 1000~/V	0-10/100/500 0-10 amp 0-100 μamp	0-2 k/200 k 0-20 meg	DB Scale
Triplett	630		0-3/12/60/300 0-1200/6000 Probe to 30 kv 20,000~/V	0-3/12/60/300 0-1200/6000 5000~/V	0-1.2/12/120 0-12 amp 0-60 μamp	0-1k/10 k 0-1 m/100 m	DB Scale
Weston	779		0-25/10/50/250 0-1000 1 k or 20 k/V	0-2.5/10/50/250 0-1000 1 k or 20 K/V	0-.1/1/10/50/250 0-1/10 amps	0-3 k/30 k/300 k 0-30 meg	DB Scales
Weston	697		0-7.5/15/50 0-750 1000~/V	0-7.5/15/50 0-750 1000~/V	0-7.5/75	0-5 k/500 k	

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— if test-equipment is not up-to-date . . . if shop-routine is not streamlined for speed?

— if you don't know the secret of picking, training, supervising the RIGHT employees?

— if you charge too little, too much, have constant "misunderstandings" with customers?

— if the parts and supplies you need are not in stock when required?

— if you don't keep proper books, never discount your bills, can't get along with your banker?

— if you never use sales-helps, never advertise, ignore elementary principles of salesmanship?

— if you "haven't time" to read about tested business methods in Service Management?

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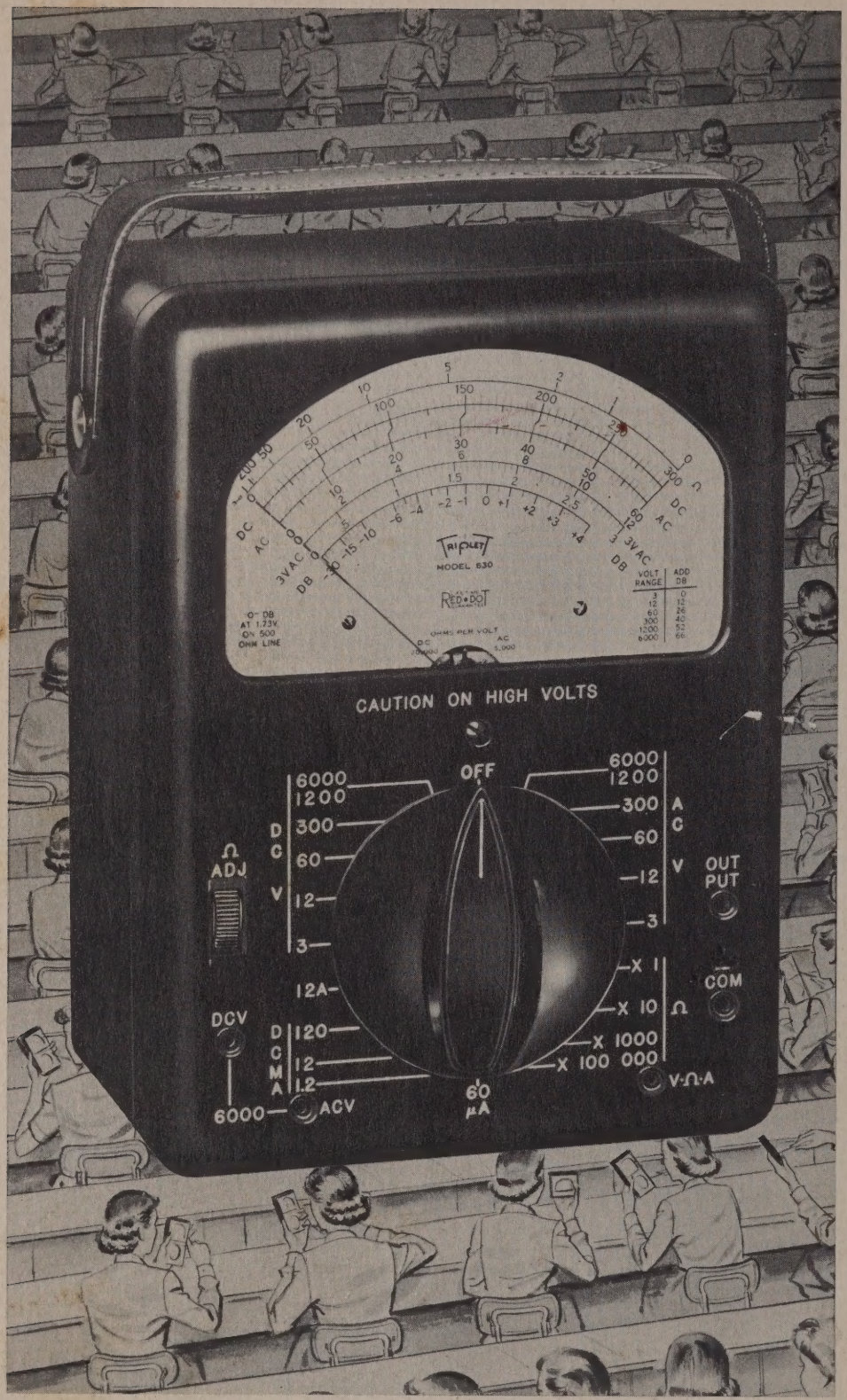

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Volt-Ohm-Mil-Ammeter

by R. L. Triplett
PRESIDENT

Because we build every major part of our instruments the quality is carefully controlled. For example, we know we have more torque driving our pointers because we designed and built the complete instrument. We know we have sustained dependence in the shafts and switch contacts of our test equipment for the same reason. Cycle tests for switches exceed several times the rigid requirements of the armed forces.

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Highest Ohm Reading—To 100 Meg. in steps of 1000-10,000-100,000 Ohms—100 Megohms.

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